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New York Statewide Residential Gas High-Efficiency Heating Equipment Programs

Evaluation of 2009-2011 Programs

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1. Executive Summary

1.1 Evaluation Objectives

The New York State Public Service Commission (PSC) approved certain utility Residential Gas HVAC (Gas High-Efficiency Heating) programs for implementation between 2009 and 2011 (Cycle 1). The following utilities in New York State administer these programs:

- Consolidated Edison Company of New York, Inc. (Con Edison)
- Orange and Rockland Utilities, Inc. (O&R)
- National Grid (The Brooklyn Union Gas Company (KEDNY), Keyspan Gas East Corporation (KEDLI), and Niagara Mohawk Power Corporation (NiMo))
- Corning Natural Gas Corporation (Corning Gas)
- Central Hudson Gas & Electric (Central Hudson)
- National Fuel Gas Distribution Corporation (National Fuel)
- Enbridge St. Lawrence Gas (Enbridge)

Through a competitive bid process, Opinion Dynamics was selected to carry out a statewide impact evaluation for the Energy Efficiency Portfolio Standard (EEPS) Proceeding Cycle 1 of the Residential Gas High-Efficiency Heating programs (HEHE Programs). The evaluation team also includes West Hill Energy & Computing and Analytical Evaluation Consultants (formerly known as Megdal and Associates). This report presents a detailed impact evaluation conducted for the New York Program Administrator (PA) Residential Gas High Efficiency Heating Equipment Program ("HEHE Programs"). The time period evaluated covers all projects installed in 2009, 2010, and 2011.

The overall objective of the statewide evaluation was to develop gas and associated ancillary electric savings impacts based on measures installed through the HEHE Programs for all participating PAs in New York State. More specifically, through the research activities conducted, the evaluation accomplishes the following:

- Reviewed savings assumptions and proposed recommendations for revisions to the *New York Standard Approach for Estimating Energy Savings from Energy Efficiency Programs* Technical Manual (NYTM)[1]
- Developed and applied gross savings realization rates
- Developed estimates of free ridership and spillover for an overall estimate of net-to-gross ratios (NTGR)
- Developed measure-specific incremental cost estimates

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[1] New York Department of Public Service's *New York Standard Approach for Estimating Energy Savings from Energy Efficiency Programs,* October 15, 2010, (a.k.a. the New York Technical Manual or NYTM). http://www.dps.ny.gov/TechManualNYRevised10-15-10.pdf.

The evaluation resulted in statistically valid gross and net impacts, with segmentation by measure category and PA where reliable estimates proved feasible given the sample size. To the degree possible, we used the impact evaluation to derive insights and provide actionable recommendations that can help improve program design, implementation, savings estimation, and data tracking.

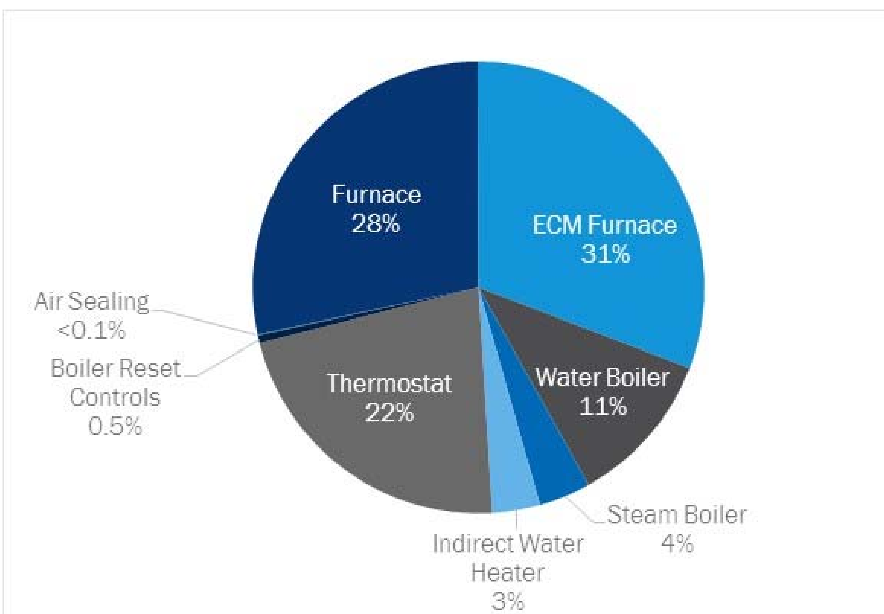
The evaluation complies with the requirements of the Evaluation Guidelines issued by the DPS (established August 7, 2008, and updated in November 2012) to support rigorous and transparent evaluation. Per the Evaluation Guidelines, the impact evaluation methods used in this report followed the recommendations provided in the Regional EM&V Methods Guidelines, developed by the NEEP EM&V Forum.

1.2 Program Summary

The HEHE Programs are open to all residential customers and are funded by those customers' System Benefit Charges (SBC) (i.e., they pay the SBC on their natural gas utility bill). The programs promote the purchase and installation of energy-efficient heating and water heating equipment. Rebates are available to qualifying customers to offset the upfront incremental costs associated with the purchase of high-efficiency equipment. Qualifying equipment is largely the same across PAs, and includes natural gas furnaces, boilers, indirect water heaters, and related add-on measures such as programmable thermostats, boiler reset controls (in some cases), and air sealing (in some cases).

The HEHE Programs had approximately 57,000 participants between 2009 and 2011. The majority of statewide ex ante savings are associated with high-efficiency furnaces (59%), programmable thermostats (22%) and boilers (15%). Figure 1-1 summarizes ex ante program savings by measure.

Figure 1-1. Program Reported Natural Gas Savings by Measure



Source: Program tracking data; evaluation team analysis

1.3 Evaluation Methods

The Evaluation Team used a combination of telephone surveys, in-depth interviews, customer billing data analysis, and engineering analysis in this evaluation.

Analysis of gross natural gas impacts relied on three complementary approaches:

1. Customer-level regression analysis to develop full-load hour (FLH) values for heating equipment
2. A pre/post billing analysis using a fixed-effects regression model to estimate retrofit savings for measure installation
3. Supplementary engineering analysis to characterize savings from indirect water heaters

This three-fold approach provided internal cross-checking and robust savings estimation. Based on these analyses, we developed and applied gross savings realization rates.

The net impact analysis is based on a telephone survey of 1,363 participating customers and 54 participating contractors and includes estimation of free-ridership and participant spillover. Non-participant spillover was outside the scope of this evaluation.[2]

Incremental cost estimates are based on a telephone survey of 110 participating contractors.

1.4 Key Findings

1.4.1 NYTM Review

- Air Sealing. The NYTM contains two algorithms for this measure. The algorithm using blower door test information is well specified. Our billing analysis found a realization rate of 93% for this measure, indicating that the savings algorithms and assumptions used by the PAs provide a good estimate of actual savings.
- Boilers & Furnaces. We find the algorithm to be reasonable and comparable to those used elsewhere, but our billing analysis indicates that, if using NYTM default assumptions, the engineering algorithm overestimates savings. This overstatement can be attributed to NYTM default FLH values considerably higher than those produced in our billing analysis.
- Boiler Reset Controls. We find the algorithm for boiler reset controls to be well specified, with one exception: the algorithm assumes that multiple controls would increase the savings of a single boiler.[3] While different controls in commercial applications can control different systems, it is unclear how additional controls would provide additional savings for residential applications when the customer has only one boiler. Inputs to the algorithm are simple and well defined, and default values suggested

[2] A future comprehensive statewide effort is planned to address non-participant spillover.

[3] During the DPS review process, the TecMarket team clarified that the "units" term in the boiler reset control algorithm refers to the number of controllers installed by the program. The evaluation team has added a recommendation that this be clarified in future versions of the Tech Manual.

for heating unit capacity when customer-specific data are not available are reasonable, with the exception of overstated full-load hour values.

- Duct Sealing. The NYTM algorithm is relatively similar to those used in other TRMs. However, it does not include a factor accounting for furnace efficiency, and therefore excludes interactive effects.
- EC Motors. The Wisconsin study upon which the deemed savings value is based includes savings in the summer and was conducted in an area of the country that, based on the 2009 Residential Energy Consumption Survey,[4] has a greater penetration of central air conditioning than New York. As such, the overall savings may be overstated.
- Indirect Water Heaters. The NYTM includes an algorithm input called UA_{base} that can cause large changes in estimated savings, yet two of the specific inputs to the algorithm are not documented. UA_{base} values for seemingly similar baseline water heaters in different NYTM sections vary substantially. In addition, the algorithm does not consider summer losses associated with IWHs that replace standard water heaters.
- Programmable Thermostats. This measure uses good engineering inputs, but may not accurately reflect how customers use their thermostats. We found the NYTM algorithm is simple and well defined, and default values suggested for heating unit capacity (when customer-specific data are not available) are reasonable. However, multiple recent evaluations[5,6] – as well as the billing analysis conducted in this current evaluation – have found lower-than-expected programmable thermostat savings, calling the 6.8% ESF used in the NYTM into question.

1.4.2 Gross Impacts

The estimated statewide gross realization rate is 53%. The rate ranges from 50% for National Fuel to 68% for Corning. Applying the realization rate to total ex ante therm savings yields total ex post savings of almost 8 million therms.

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[4] Residential Energy Consumption Survey (RECS). U.S. Energy Information Administration (August, 2011).

[5] *NYSERDA 2007-2008 EmPower New York[SM] Program Impact Evaluation Final Report,* prepared for the New York Energy and Research Development Authority by Megdal and Associates. April 2012. Page ES-8.

[6] *NYSERDA 2007-2008 Home Performance with Energy Star® Program Impact Evaluation Final Report,* prepared for the New York Energy and Research Development Authority by Megdal and Associates. September 2012. Page 4-7.

Table 1-1. Summary of Gross Savings (2009-2011)

PA	Ex Ante Program Savings (Therms)	RR	Ex Post Program Savings (Therms)
Central Hudson	194,782	57%	111,406
Con Edison	863,985	52%	448,550
Corning	119,180	68%	81,531
Enbridge	91,348	61%	55,675
National Fuel	6,560,295	50%	3,264,486
KEDLI	955,067	61%	582,657
KEDNY	668,990	62%	416,473
NiMo	5,224,681	54%	2,797,021
O&R	325,988	63%	204,486
Statewide	15,004,317	53%	7,962,286

Statewide realization rates for measures incented by the residential HEHE Programs range from 22% for thermostats to 93% for sealing. Realization rates for heating systems range from 60% to 69%. Thermostats have the biggest impact on overall realization rates. While they have relatively small per unit ex ante savings, they are the most frequently installed measure and have by far the lowest realization rate. Heating systems have the second biggest impact on overall ex post savings.

Other findings are detailed below:

- **Data Collection and Program Tracking.** Some PAs used default values for necessary inputs to savings calculations (such as equipment capacity). Further, not all PAs were applying NYTM algorithms in the same manner. For example, each PA could choose FLH assumptions based on vintage and home type, and therefore each PA may have had different criteria for assigning these values. Some PAs used default values as inputs instead of household-specific values. These tracking differences have implications for realization rates.

- **Savings Assumptions for Heating System Replacement.** Full load hours for heating system replacement estimated through this evaluation indicate that assumptions in the NYTM (for an average single-family home) may be overstated by as little as 16% to as much as 41%. If the FLH values estimated in this evaluation were applied to 2009-2011 ex ante savings, realization rates would be between 59-81%, depending on the program administrator.

- **Savings Assumptions for Programmable Thermostats.** This evaluation showed that the current energy savings factor of 6.8%, stipulated by the NYTM, is not realistic among HEHE program participants. The realization rate for thermostat savings was 22%, and programmable thermostats appeared to save about 2% of average annual pre-installation natural gas consumption based on billing analysis.

- **Savings Assumptions for Boiler Reset Controls.** While the realization rate for boiler reset controls was 63%, the pre/post billing analysis showed that actual percent savings are in line with the energy savings factor (ESF) in the NYTM.

- **Savings Assumptions for Indirect Water Heaters.** The current NYTM algorithm does not currently account for a reduction in operating efficiency during summer months. The decrease in efficiency would be applicable to households that switch from a standard natural gas-fired water heater to a large boiler with an indirect hot water heater. In addition, the NYTM also uses an algorithm to calculate the heat loss coefficient for the baseline water tank, but not all values in the algorithm are documented. The resulting heat loss coefficient is higher than most other sources and higher than the deemed heat loss coefficient for standard hot water heaters in other areas of the NYTM.

1.4.3 Net Impacts

The estimated statewide NTGR for the evaluation period (2009-2011) is 61.8%. We estimate free-ridership to be 38.5% and participant spillover 0.3%. The NTGR ranges from 71.0% for KEDLI to 48.2% for Orange & Rockland (O&R). Free-ridership ranges from just under 30% for KEDLI to approximately 50% for O&R, Corning, and Enbridge. Participant spillover is uniformly low across PAs, ranging from no spillover for Enbridge and O&R to 1.5% for Corning.

Table 1-2 summarizes the program-level FR, participant SO, and NTGRs.

Table 1-2. Program Level NTGRs

PA	Program Free-Ridership	Program Spillover	Program NTGR
Central Hudson	31.8%	0.5%	68.8%
Con Edison	36.5%	0.5%	64.1%
Corning	50.4%	1.5%	51.1%
Enbridge	47.8%	0.0%	52.2%
National Fuel	36.9%	0.3%	63.4%
KEDLI	29.6%	0.6%	71.0%
KEDNY	37.5%	0.4%	62.9%
NiMo	41.5%	0.3%	58.8%
O&R	51.8%	0.0%	48.2%
Statewide	38.5%	0.3%	61.8%

Table 1-3 below presents ex post net impacts for 2009 to 2011, by PA and statewide, calculated by multiplying ex-post gross impact results by the NTGR.

Table 1-3. Program Level Net Impacts (2009-2011)

PA	Ex-Post Gross Impacts (Therms)	Program Level NTGR	Ex-Post Net Impacts (Therms)
Central Hudson	111,406	68.8%	76,596
Con Edison	448,550	64.1%	287,313
Corning	81,531	51.1%	41,673
Enbridge	55,675	52.2%	29,057
National Fuel	3,264,486	63.4%	2,070,017
KEDLI	582,657	71.0%	413,603
KEDNY	416,473	62.9%	261,855
NiMo	2,797,021	58.8%	1,644,122
O&R	204,486	48.2%	98,639
Statewide	7,962,286	61.8%	4,922,876

1.4.4 Incremental Cost

This evaluation included estimation of incremental costs for the four major measures incented through the Programs: furnaces, water boilers, steam boilers, and indirect water heaters. We estimated incremental costs for various efficiency levels, corresponding to efficiency levels rebated by the PAs through the Programs. Table 1-4 provides mean and median incremental cost estimates. Results are presented for two analytical approaches developed as part of this evaluation (described in more detail in Sections 3.4 and 4.4). Except for steam boilers (82% AFUE), the results of the two approaches are nearly identical.

Table 1-4. Weighted Incremental Cost Estimates

Measure	Approach #1			Approach #2		
	n	Mean	Median	n	Mean	Median
Furnace – 90% AFUE	46	$835	$700	31	$889	$650
Furnace – 92% AFUE	41	$1,062	$900	27	$1,022	$800
Furnace – 94% AFUE	35	$1,317	$1,200	25	$1,169	$1,000
Furnace – 95% AFUE	56	$1,295	$1,200	35	$1,349	$1,100
Water Boiler – 85% AFUE	25	$669	$500	24	$679	$500
Water Boiler – 90% AFUE	22	$2,073	$2,000	21	$2,072	$1,800
Steam Boiler – 82% AFUE	35	$130	$500	24	$442	$500
Indirect Water Heater	33	$955	$1,105	32	$944	$950

1.5 Evaluation Recommendations

- **NYTM Review.** We recommend dialogue among New York stakeholders (i.e., the PAs, the Technical Manual Review Committee, the DPS, and the TecMarket team) about potential updates to the NYTM:
  - **Air Sealing.** We suggest revisions to the NYTM text to clarify the meaning of the term incorporating heating and distribution system efficiency.
  - **Boilers & Furnaces.** To better align future estimates of savings with actual values, we suggest the NYTM estimates of full-load hours be updated in accordance with this study, which will reduce expected savings to better align with the results of this billing analysis.
  - **Boiler Reset Controls.** We recommend clarifying the “units” variable in the NYTM algorithm for boiler reset controls to reflect that savings for only one control can be claimed for each boiler in the residential sector. Additionally, to better align future estimates of savings with actual values, we suggest the NYTM estimates of full-load hours be updated in accordance with this study, which will reduce expected savings to better align with the results of this billing analysis. However, if FLH values are not updated, we suggest additional research to verify ESF values could be valuable.
  - **Duct Sealing.** We suggest revising the NYTM algorithm to include a term accounting for furnace efficiency, and therefore interactive effects.
  - **EC Motors.** We recommend performing additional New York-specific research into the parameters in the Wisconsin algorithm to more accurately quantify savings for the state of New York.
  - **Indirect Water Heaters.** We suggest revising the information listed in the NYTM to specify more clearly the source of its assumptions. Alternatively, for larger-sized water heaters where stand-by loss data is available, more standardized estimates of UA_{base} could be used, such as the formula suggested by ASHRAE. We also suggest to consider inclusion of a term to cover summer losses in the NYTM algorithm for indirect water heaters. Finally, we recommend updates to the NYTM to more clearly explain the variation in UA_{base} values for seemingly similar baseline water heaters in different NYTM sections or, if necessary, to make values more consistent.
  - **Programmable Thermostats.** We suggest further research into the appropriate choice of ESF for programmable thermostats in New York. If further research aligns with recent findings, a change in the ESF specified may be necessary.
- **Gross Impacts.** Based on our gross impact analysis, we make the following recommendations:
  - **Data collection and program tracking.** We recommend that PAs continue to improve data collection and program tracking practices. We also recommend to consider adding a database “check” task into future evaluations to enable periodic review of data quality and ensure consistency in how algorithms are applied.
  - **Selection of Baseline.** For this study, we defined the baseline as the federal standard. However, we note that definition of the baseline can significantly influence savings results. If the standard market practice baseline exceeds federal standards, our estimated ex post savings would be overstated. Determining the most appropriate baseline for each measure was outside the scope of this study. However, given the sensitivity of results to the selection of the baseline, we recommend future research into this issue.

- **Replacement on Failure versus Early Replacement.** We recommend that PAs track the efficiency and/or age of the replaced equipment and whether the equipment was still functioning at the time of replacement, if feasible. This would provide additional information on the extent to which early replacement is taking place.[7]
- **Savings Assumptions for Heating System Replacement.** We recommend additional dialogue with New York stakeholders (i.e., the PAs, the Technical Manual Review Committee, the DPS, and the TecMarket team) about potential updates to residential heating equipment FLH assumptions in the New York Technical Manual. If stakeholders wish to modify FLH assumptions for planning purposes, we would recommend applying an adjustment factor to FLH assumptions in the NYTM (see page 431 of the October 15, 2010 NYTM) based on the average difference between FLH assumptions in the NYTM and evaluated Ex Post FLH. This adjustment factor is detailed later in this report.
- **Savings Assumptions for Programmable Thermostats.** Based on the low realization rate noted in this analysis, we suggest that thermostat savings assumptions in the NYTM be updated, taking into account program delivery. We understand that programmable thermostats may be installed through other delivery channels, and that savings may differ depending on the program population or delivery approach. As such, we recommend reviewing ex post savings observed in this and other evaluations or conducting additional research across multiple program designs (including this one) to determine if and how assumptions could be modified. For example, the results of this evaluation could be used to inform a revision for the HEHE Programs, while the results of other evaluation efforts could be used to update assumptions for other programs (e.g., home energy assessment) where programmable thermostats are installed.
- **Indirect Water Heaters.** We recommend incorporating data on existing system type (i.e., indirect water heater, individual natural gas boiler and storage water heater, etc.) in future evaluations to help inform what percent of the indirect water heaters installations would be subject to summer losses. Depending on the outcome of that analysis, we suggest consideration of incorporating summer losses into future impacts calculations for indirect water heaters. For the heat loss coefficient of the baseline water heater, consider updating the NYTM to consistently apply this factor across all measures that include a baseline hot water heater. Consider other references (e.g., ASHRAE) to ensure the deemed value is consistent with industry standards.

[7] If PAs choose to base savings on early replacement, Appendix M, Section 5 of the NYTM specifies the additional variables that the TecMarket team recommends be tracked in program databases.

2. Introduction

The New York State Public Service Commission (PSC) approved certain utility Residential Gas HVAC (Gas High-Efficiency Heating) programs for implementation between 2009 and 2011 (Cycle 1). The following utilities in New York State administer these programs:

- Consolidated Edison Company of New York (Con Edison)
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The evaluation complies with the requirements of the Evaluation Guidelines issued by the DPS (established August 7, 2008, and updated in November 2012) to support rigorous and transparent evaluation. Per the Evaluation Guidelines, the impact evaluation methods used in this report follow the recommendations provided in the Regional EM&V Methods Guidelines, developed by the NEEP EM&V Forum.

2.1 Program Description

The HEHE Programs are open to all residential customers and are funded by those customers' System Benefit Charges (SBC) (i.e., they pay the SBC on their natural gas utility bill). The programs promote the purchase and installation of energy-efficient heating and water heating equipment, including natural gas furnaces, boilers, indirect water heaters, and related add-on measures such as programmable thermostats, boiler reset controls (in some cases), and air sealing (in some cases). Rebates are available to qualifying customers to offset the upfront incremental costs associated with the purchase of high-efficiency equipment.

Qualifying equipment is largely the same across PAs, with a few differences in add-on measures. Table 2-1 shows which major measure categories were offered by each PA between 2009 and 2011.

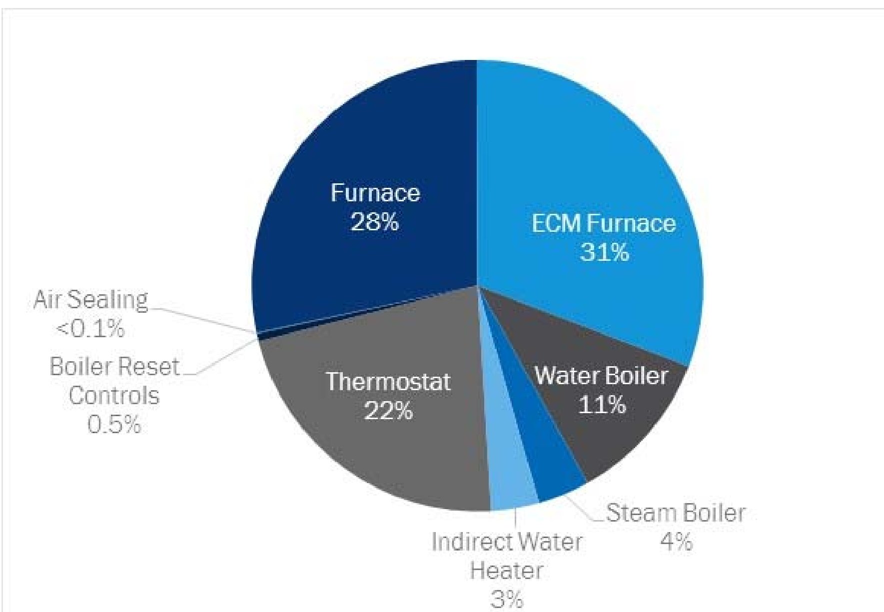
Table 2-1. Qualifying Measure Categories by PA[a]

Measure Categories	Central Hudson	Con Edison	Corning Gas	Enbridge	National Fuel	KEDLI	KEDNY	NiMo	O&R
Furnace with ECM	✓	✓	✓	✓	✓	✓	✓	✓	✓
Furnace	✓	✓	✓	✓	✓	✓	✓	✓	✓
Water Boiler	✓	✓	✓	✓	✓	✓	✓	✓	✓
Steam Boiler	✓	✓	✓	✓	✓	✓	✓	✓	✓
Indirect Water Heater	✓	✓	✓	✓	✓	✓	✓	✓	✓
Boiler Reset Controls	✓	✓	✓	✓		✓	✓	✓	✓
Programmable Thermostats	✓	✓	✓	✓	✓	✓	✓	✓	✓
Duct and Air Sealing	✓	✓		✓		✓	✓	✓	✓

[a] National Fuel provided incentives and participant data for storage tank water heaters and tankless water heaters. These measures are no longer being offered by National Fuel and are not part of this evaluation.

The majority of statewide ex ante savings from the HEHE Programs are associated with high-efficiency furnaces (59%), programmable thermostats (22%), and boilers (15%). Figure 2-1 summarizes ex ante program savings, by measure.

Figure 2-1. Program Reported Natural Gas Savings by Measure



Source: Program tracking data; evaluation team analysis

2.2 Overview of Evaluation

The statewide evaluation was designed to estimate gas and associated ancillary electric savings impacts based on measures installed through the HEHE Programs for all participating PAs in New York State. Specifically, we conducted the following activities for this evaluation:

1. **New York Technical Manual[8] (NYTM) Review:** Reviewed deemed savings assumptions and algorithms, and proposed recommendations for revisions, where needed.
2. **Gross Impact Analysis:** Estimated updated Effective Full Load Hour (FLH) values by climate zone (a key input to estimating gross savings for heating system replacement). Conducted customer billing analysis to understand gross savings by measure category. Developed and applied gross savings realization rates.
3. **Net-to-Gross Analysis:** Developed estimates of free-ridership at the program level, by PA, and at the measure level, by PA group. Developed participant spillover, by PA. Estimated PA-level net-to-gross ratios (NTGR) and applied them to ex post gross savings.
4. **Incremental Cost Analysis:** Developed measure-specific incremental cost estimates.

The Evaluation Team used a combination of telephone surveys, in-depth interviews, customer billing data analysis, and engineering analysis in this evaluation.

2.3 Organization of Report

The remainder of this report is organized as follows:

- Section 3 provides an overview of the impact methodology. This section is divided into four subsections: 1) NYTM review, 2) gross impacts, 3) net impacts, and 4) incremental costs.
- Section 4 presents the evaluation results. This section has the same subsections as the methodology section.
- Section 5 provides key findings and recommendations.
- Appendix A presents more detailed technical information for various analyses of this evaluation.
- Appendix B contains additional information on the primary data collection efforts for this evaluation.
- Appendix C contains the data collection instruments.
- Appendix D contains the glossary of terms.

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[8] New York Department of Public Service's *New York Standard Approach for Estimating Energy Savings from Energy Efficiency Programs,* October 15, 2010, (a.k.a. the New York Technical Manual or NYTM). http://www.dps.ny.gov/TechManualNYRevised10-15-10.pdf. This review included revisions to the NYTM through November 23, 2013.

3. Evaluation Methodology

3.1 New York Technical Manual Review

We conducted measure-level engineering reviews of the current algorithms and deemed savings values from the *New York Standard Approach for Estimating Energy Savings from Energy Efficiency Programs* Technical Manual (NYTM)[9], including all revisions through November 26, 2013, to ensure that they are current and appropriate for all program measures.[10] We compared algorithms and assumptions currently in the NYTM with data from the most recent and regionally appropriate data sources available (see Table 3-1 below). For indirect water heaters, which make up only 3% of reported gross savings from programs, we closely reviewed the results of this evaluation's billing and engineering analyses (described below). The objective of the review was to highlight any areas of uncertainty and provide suggested updates to the NYTM, where needed.

Table 3-1. Technical Manuals and Other Sources Referenced in Review of NYTM

Measure Categories	TRMs Referenced			Other Sources[a]
	Mid-Atlantic	Massachusetts	Illinois	
Air Sealing			X	
Boilers	X	X	X	
Boiler Reset Controls		X	X	
Duct Sealing	X		X	
EC Motors	X	X	X	X
Furnaces	X	X	X	
Indirect Water Heaters		X		X
Programmable Thermostats	X	X	X	X

[a] Sources are cited in each section, and include evaluations either cited in the NYTM as the source for savings assumptions, or evaluations we felt were relevant.

[9] New York Department of Public Service's *New York Standard Approach for Estimating Energy Savings from Energy Efficiency Programs,* October 15, 2010, (a.k.a. the New York Technical Manual or NYTM). http://www.dps.ny.gov/TechManualNYRevised10-15-10.pdf.

[10] Additional revisions to the NYTM were released on March 17, 2014. Because evaluation activities were completed at this time, this report does not incorporate these revisions.

3.2 Gross Impact Methods

The objectives of the gross impact analysis were to:

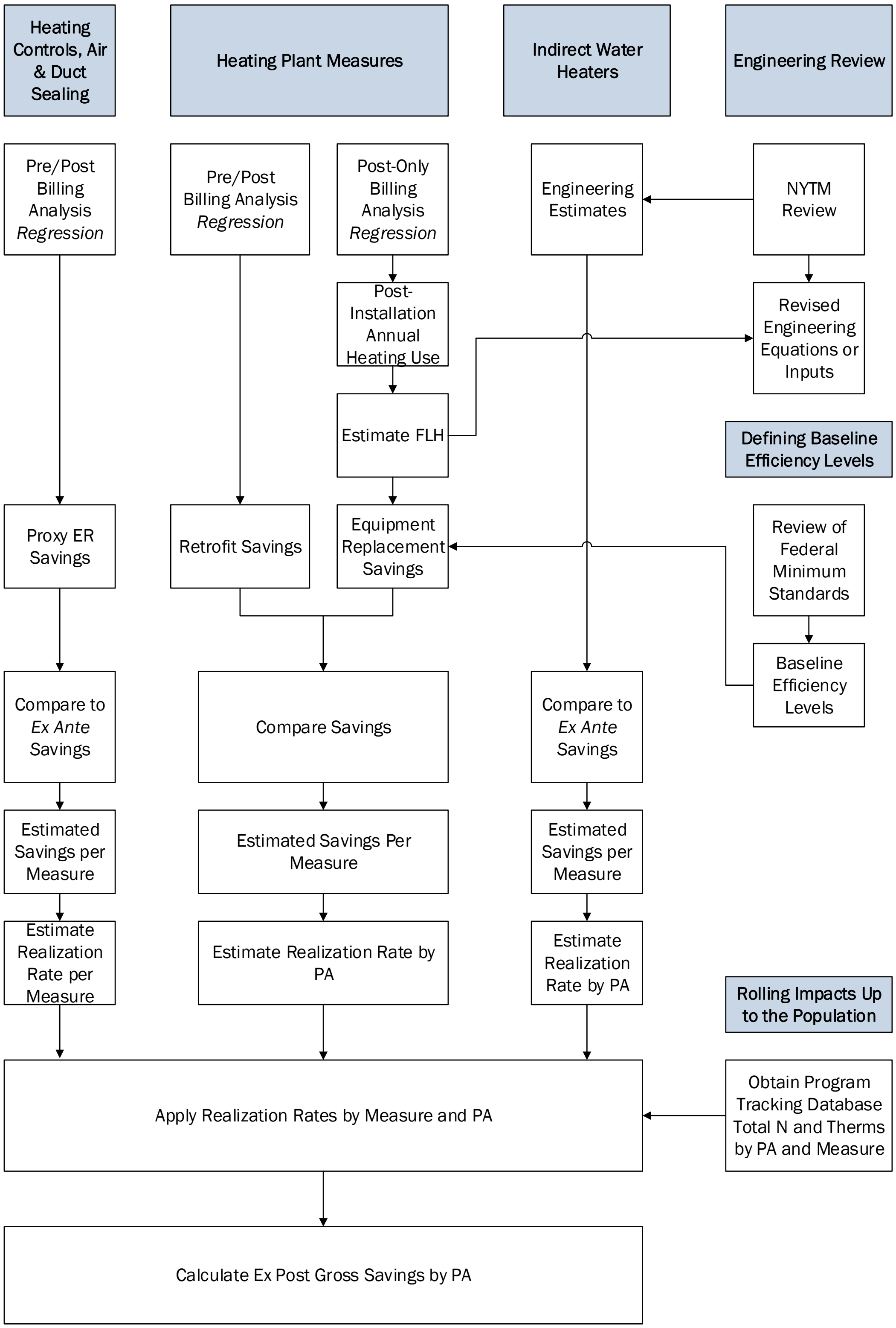
- Provide reliable estimates of first-year gross natural gas savings from equipment replacement
- Use empirical data to calculate effective full-load hours for the gas measures within our analysis and compare with the NYTM

Analysis of gross natural gas impacts relied on three complementary approaches:

1. Customer-level regression analysis to develop full-load hour (FLH) values for heating equipment
2. A pre/post billing analysis using a fixed-effects regression model to estimate retrofit savings for measure installation
3. Supplementary engineering analysis to characterize savings from indirect water heaters

This three-fold approach provided internal cross-checking and robust savings estimates. Figure 3-1 presents the gross impact evaluation approach graphically. We outline the specifics of our approach and any changes from the work plan in the subsections that follow.

Figure 3-1. Gross Impact Evaluation Approach



It should be noted that the impact analyses in this study are based on the assumption of replacement on failure (rather than early replacement) and a definition of the baseline as the federal standard. These assumptions are consistent with how PAs claim savings, and they were documented in the approved work plan. However, we note that both of these assumptions can significantly influence savings results. For example, if the standard market practice baseline exceeds federal standards, our estimated ex post savings would be overstated. Conversely, savings for equipment that is replaced early would be higher than savings for equipment replaced on failure, if the replaced equipment is less efficient than the baseline. Determining the most appropriate baseline for each measure and evaluating savings based on early replacement was outside the scope of this study. However, given the sensitivity of results to these assumptions, we recommend future research into both selection of baseline and assumptions with respect to replacement on failure versus early replacement.

3.2.1 FLH Methodology

One of the more important components of determining savings for heating systems based on engineering algorithms is the full-load hours (FLH) input value. This value simplifies analysis so the capacity of the heating unit and the FLH determine the output of the system. By using actual therm use from bills and an innovative billing analysis method, our team calculated updated FLH values.

The FLH analysis included the following steps, in sequential order:

1. Clean program-tracking and billing data to identify homes for inclusion in a post-installation heating consumption model. Criteria for inclusion were (a) presence of heating system measures, (b) sufficiency of billing data, and (c) completeness of measure information (from program-tracking data)

2. Model annual heating consumption for each home in the FLH analysis, using their post-installation billing history and weather from the nearest weather station (where we used actual weather to build the models, and 10-year normalized weather to make predictions from the models)

3. Calculate full-load hours for each home in the FLH analysis, using annual heating use in the post-period (modeled in the second step above) and input capacity (from program-tracking data)

4. Aggregate results by the six climate zones used in the NYTM

5. Calculate realization rates by PA, and apply realization rates to estimate total savings

In addition to the steps outlined above, we compared results with other recent evaluations and the NYTM, and tested what our results might be with slightly different long-term weather assumptions.

In the sections below, we describe the methodology for the FLH analysis and calculation of realization rates for heating systems. We also describe steps we took to confirm that the customers included in the FLH analysis were representative of all customers with heating equipment installations, despite high drop rates within the analysis for a few program administrators (PAs).

Data Used in Analysis

To estimate FLH, the billing analysis required three major types of data:

- Program data on measures installed in each home, and measure characteristics
- Consumption history (billing records) from PAs

- Weather data, provided by the National Oceanic and Atmospheric Administration's (NOAA) National Climatic Data Center (NCDC)

The sections below describe how this data was prepared and used in analysis.

Cleaning Program-Tracking and Billing Data

The first step in the process was to clean and combine the billing and program data. We identified the measures installed in each home and the project completion date from program tracking data. The basic requirements for inclusion in the FLH post-installation billing analysis were as follows:

- Program-tracking data includes information on heating system input capacity and efficiency
- Sufficient and reliable post-installation billing data was available
- Installed a single high-efficiency heating system (i.e., residences recorded as installing more than one heating system were excluded)

Overall, we included 44% of all participants with a heating system installation in the final analysis. This rate varied substantially between PAs, from a maximum of 91% of records retained for O&R and Enbridge, to a minimum of 2% of records retained for KEDLI (see Table 3-2). The greatest number of records were dropped due to missing program-tracking data, such as the capacity of the installed heating system (which is required to convert annual heating consumption to FLH). We note this drop was proportionally highest for KEDLI and NiMo.

Because of the extent of participant drops among some utilities, particularly KEDLI and KEDNY in the NYC climate zone, we aggregated results to the climate zone level (i.e., Con Edison, KEDLI, and KEDNY contribute to NYC values, and Central Hudson and O&R contribute to Poughkeepsie values). All other climate zones are comprised of a single PA.

Table 3-2. Count of Participants Included in FLH Analysis[a]

PA	Central Hudson	O&R	Corning	Enbridge	National Fuel	Con Edison	KEDLI	KEDNY	NiMo	TOTAL
Climate Zone	Pough-keepsie	Pough-keepsie	Bing-hamton	Massena	Buffalo	NYC	NYC	NYC	Albany/ Syracuse	
Unique Participants in Participant File	614	1,054	398	295	26,954	2,435	5,463	3,982	15,821	57,016
Billing data not available for participant	23	9	24	6	860	218	182	21	2,251	3,594
Anomalous or insufficient post-period billing data	32	48	123	22	1,282	100	474	768	59	2,908
No heating system installation	43	154	1	-	1,700	62	568	323	130	2,981
Multiple heating system installations	9	19	4	-	243	69	1	44	68	457
Missing, insufficient, or out-of-range program-tracking data[11]	260	1	4	-	6,305	38	4,140	2,297	10,114	23,159
Heating use not weather-dependent or questionable FLH	2	8	3	1	245	28	11	23	22	343
n Remaining	245	815	239	266	16,319	1,920	87	506	3,177	23,574
% Remaining (of all participants)	*40%*	*78%*	*61%*	*91%*	*61%*	*80%*	*2%*	*13%*	*20%*	*42%*
% Remaining (of heating system n)	*43%*	*91%*	*61%*	*91%*	*66%*	*82%*	*2%*	*14%*	*20%*	*44%*

[a] This table shows the number of unique participants dropped for each category of reasons.

Our analysis of the billing data found that the billing records for some utilities showed a "see-saw" pattern, with one estimated read followed by one actual read. For these homes, we collapsed each pair of reads (estimated followed by actual) into one, and used the two-month period to provide a clearer picture of the relationship between weather and heating use, and to estimate annual consumption.

Weather Data

The weather data in billing analysis models is from the weather station (airport) that is geographically closest to each participant's ZIP code, from among 32 weather stations in New York and surrounding states - see Appendix Table A-4 for a list of stations. The weather data for analysis came from NOAA's National Climatic Data Center. To model the relationship between weather and natural gas use for each home, we calculated the heating and cooling degree-days for each billing cycle for each home using actual weather data from the nearest weather station. To calculate the average FLH by climate zone, we used average 10-year normalized heating degree-days from the nearest weather stations of all 2009-2011 HEHE program participants (where 10-year normal values span 2003-2012). We also examined FLH values using Typical Meteorological Year (TMY3) data from the National Renewable Energy Laboratory, which is compiled from 1991-2005

[11] Capacity and AFUE were required for the FLH analysis. This information is collected if provided on a customer's rebate application form. However, participants are not required to provide this information.

climatological data. We use this TMY3 data for comparison purposes only, to show the small differences in FLH estimates that exist when different long-term values are used (see Table 4-7 for results of this comparison).

Post-Installation Heating Consumption Model

Annual natural gas consumption in the period following installation of the efficient heating system is an important input for estimating equipment savings. To calculate annual heating consumption for each home, we conducted separate linear regression models for each home, using only post-installation billing data. The models regress average daily natural gas consumption on average daily heating degree days (HDD) for each billing period (monthly or bi-monthly, depending on how the customer is billed). We used a base temperature of 65 degrees to calculate HDD (HDD65). We tested models with and without intercepts (reflecting therms of base use) for each home, and selected one model for each home:

- If the intercept was negative, the no-intercept model was selected (indicating no base use[12])
- If the intercept was positive, the intercept model was selected (indicating base use, such as natural gas water heating)

We recorded three results from each model:

1. The R^2, which reflects the strength of the relationship between heating degree days and consumption
2. The heating estimator (slope coefficient in therms/HDD), which reflects the magnitude of the relationship between heating degree-days and consumption
3. The intercept, which reflects therms of base use

We used the intercept and heating estimator to calculate annual heating consumption, using the formula:

Annual Heating Use = Heating Slope (therms/HDD) x Normalized HDD

Where:

Annual Heating Use = Normalized therms per year used for space heating

Heating Slope = Regression estimator for the HDD (therms/HDD)

Normalized HDD = 10-year normalized HDD65 for nearest weather station

Further, we used the R^2 from each model to determine whether the house used natural gas as its primary or secondary space heating fuel (as described in the next section), and to identify households to keep in the final analysis.[13]

[12] For these homes, the model did not pick up any non-heating natural gas use (e.g., the home may have an electric water heater, cooktop/oven or clothes dryer, or the use from any of these was too small to stand out from the weather-dependent (heating) usage).

[13] A few homes (less than 1%) were removed from the model as the regression showed unexpected results, such as a very weak or negative relationship between natural gas use and heating degree days.

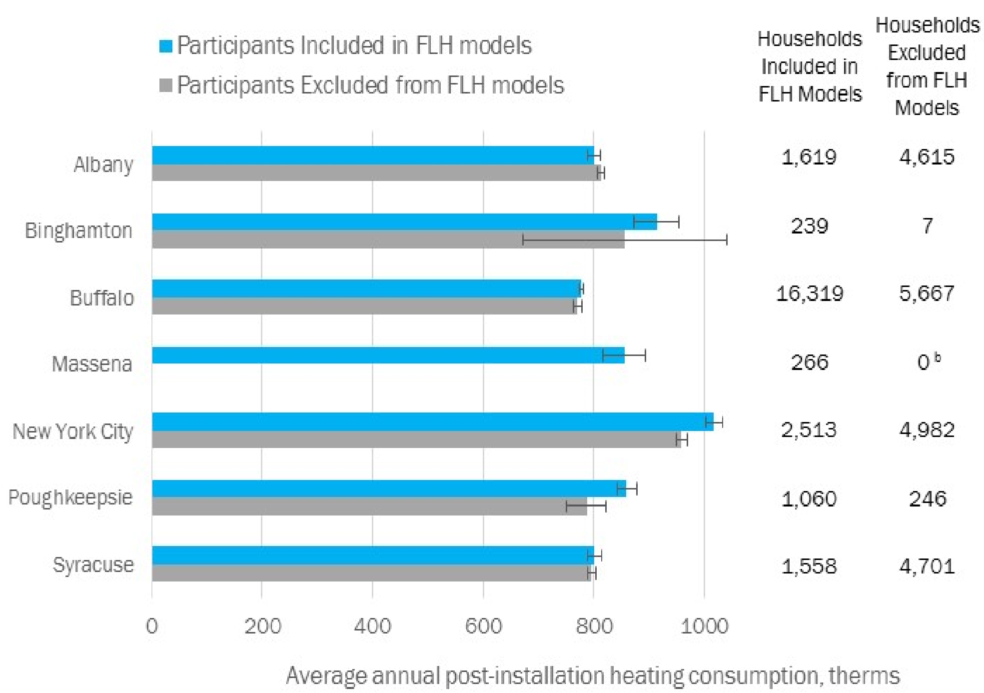
Analysis of Participants with Billing Data Included and Excluded from FLH Analysis

We performed an additional analysis to assess whether the participants in the post-installation FLH analysis are representative of other program participants. The analysis involved comparing annual heating consumption for two types of customers:

- Participants who were included in the FLH model (who had sufficient billing and program tracking data) (n=23,574)
- Participants who installed heating equipment and had sufficient billing data to estimate annual heating consumption, but were excluded from the FLH models due to missing or insufficient program tracking data (n=20,218)

Billing data was sufficient to estimate annual heating consumption for more than 43,000 HEHE participants, almost twice the number of customers included in the FLH analysis. Figure 3-2 compares annual heating use of homes included in the FLH analysis to that of homes excluded from the FLH model (but for whom billing data was available) at the climate zone level. This analysis showed that for four climate zones, the annual heating consumption of participants included and excluded from the FLH analysis is (statistically) equivalent. While two climate zones (New York City and Poughkeepsie) show a statistically significant difference in annual consumption between homes included and excluded from the FLH analysis, the practical differences are is small. Based on this limited data available to compare participants, it appears that participants included in FLH model are generally representative of the wider program population.

Figure 3-2. Comparison of Estimated Annual Heating System Consumption by Climate Zone between Participants Included and Excluded from FLH Analysis [a]



[a] Error bars reflect the 90% confidence interval.

[b] All participants in the Massena climate zone (Enbridge St. Lawrence) with sufficient post-installation heating data were included in the FLH analysis.

Calculation of FLH and Savings

Calculation of FLH

Using normalized post-installation annual heating use estimates for each household, we calculated FLH for each home, using the formula:

$$FLH = \frac{Annual\ Heating\ Use_{Post}\ (Btu)}{Input\ Capacity\ \left(\frac{Btu}{hr}\right)}$$

We used the input capacity value for the new heating system recorded in the program-tracking data to calculate FLH for each household.[14]

Aggregating FLH

We grouped the households based on each model's R^2 value, to try to distinguish between homes that use natural gas as their primary and only heating fuel, and homes that may have a secondary source of space heat. We divided homes with heating systems into the following categories:

1. No Natural Gas Space Heat (SH) or Bad Data: $R^2 < 0.30$, assumed to be bad data (less than 1% of homes)
2. Secondary Source of Space Heat: $R^2 >= 0.30$ and $R^2 < 0.70$ – likely to have another source of heat in addition to natural gas (about 5% of homes)
3. Primary Space Heat is Natural Gas: $R^2 >= 0.70$ – using natural gas as primary heat source (about 94% of homes)

We retained all households with an R^2 value of at least 0.3 in the analysis. We considered households with an R^2 value of at least 0.70 as having natural gas as the primary space heating fuel and homes with an R^2 value of 0.3-0.7 as using natural gas along with a secondary source of space heat; these homes accounted for 1,166 or 4.9% of those in the analysis. Homes with a secondary source of space heat had noticeably lower FLH than homes with stronger model fit, which aligns with less use by the natural gas equipment. Because the use of secondary space heat by a fraction of program participants is expected, these homes (R^2 value of 0.3-0.7) were included in the analysis. Estimated FLH values thus reflect a weighted average of values for homes with natural gas as primary and secondary sources of space heat.

Ex Post Savings Calculation

The penultimate step is calculating ex post savings as a function of new FLH estimates, using the following equation:

$$Ex\ Post\ Savings = FLH\ x\ capacity_{new}\ x\ \frac{\eta_{efficient} - \eta_{baseline}}{\eta_{baseline}}$$

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[14] Note that this equation is different from the equation set forth in the evaluation plan, which included a multiplicative term for AFUE. That equation assumed that capacity data in the program-tracking data would be the output capacity. This equation is consistent with the NYTM, which uses heating equipment input capacity in its equations.

Where:

$Capacity_{new}$ = the input capacity of the high-efficiency (HE) heating system from program records

FLH = estimated average full-load hours for each household

$\eta_{baseline}$ = the AFUE of the baseline efficiency equipment, defined by federal standards

$\eta_{efficient}$ = the average AFUE from program records

Table 3-3 below shows a summary of program-qualifying efficiency levels by heating system type.

Table 3-3. Minimum Qualifying Heating System Efficiency by PA

Measure	National Fuel	Other PAs	Federal Baseline
ECM Furnace	0.90	0.92	0.78
Furnace	0.90	0.90	0.78
Water Boiler	0.85	0.85	0.80
Steam Boiler	0.81	0.82	0.75

Realization Rate Calculation

Once we determined the evaluated gross savings as described above, we calculated average per-unit realization rates by dividing the evaluated ex post gross savings by the program-reported ex ante gross savings. For heating systems, we calculated realization rates at a PA level because of differences in how PAs calculate savings in program-tracking databases. We examined PA databases to determine if PAs used the same set of inputs for the same measures (e.g., similar FLH values from the TRM, customer versus average capacity and efficiency values, custom or deemed savings, etc.), and we concluded that there are likely numerous differences in how PAs apply NYTM assumptions and calculate savings on a service territory specific basis. Therefore, we calculated realization rates at a PA level.

3.2.2 Pre/Post Billing Analysis Methodology

Data Sources

We estimated the change in gas usage using a pre/post billing analysis. This analysis provides an upper bound to the actual energy savings available through the installation of program measures, which we estimated as described in the previous steps. Similar to the FLH analysis, the pre/post analysis required three major types of data: program data on the measures installed in each home, consumption history (billing records) from PAs, and weather data (actual weather data from the program period, and 10-year weather normals). Unlike the FLH analysis, the pre/post approach compares household consumption before and after the installation of efficient measures; thus, a longer billing history was necessary. As described below, this had a significant impact on the number of participants who could be included in the pre/post model.

Cleaning Program-Tracking and Billing Data

Overall, we included 69% of all participants within the final pre/post analysis. This rate varied between PAs, from a maximum of 82% of records retained for National Fuel, to a minimum of 17% of records retained for Con Edison. The greatest number of records were dropped due to insufficient billing data (i.e., billing data did not span a long enough time period to be included in the analysis).

Table 3-4. Count of Participants Included in Pre/Post Billing Analysis

PA	Central Hudson	O&R	Corning	Enbridge	National Fuel	Con Edison	KEDLI	KEDNY	NiMo	TOTAL
Climate Zone	Pough-keepsie	Pough-keepsie	Bing-hamton	Massena	Buffalo	NYC	NYC	NYC	Albany/ Syracuse	
Unique Participants in Participant File	*614*	*1,054*	*398*	*295*	*26,954*	*2,435*	*5,463*	*3,982*	*15,821*	*57,016*
Missing account number or billing data	23	9	24	6	860	218	182	21	2,251	3,594
Missing or insufficient billing data	341	154	154	100	3,609	1,787	3,478	1,426	1,958	13,007
Winter zero reads	2	10	1	4	152	12	-	52	59	292
Extremely high usage	2	20	11	3	191	14	212	153	54	660
Low program reported savings	10	-	1	6	-	1	1	2	9	30
Multiple heating systems	-	2	2	-	39	1	18	2	13	77
Total Dropped	378	195	193	119	4,851	2,033	3,891	1,656	4,344	17,660
n Remaining	236	859	205	176	22,103	402	1,572	2,326	11,477	39,356
% Remaining (of all participants)	*38%*	*81%*	*52%*	*60%*	*82%*	*17%*	*29%*	*58%*	*73%*	*69%*

Pre/Post Regression Model

Upon completion of the data aggregation and cleaning effort, the evaluation team applied a generalized cross-sectional-time-series linear model to the billing data, and tested multiple specifications of this model (described in Appendix A). The model includes weather effects as predictor variables, and uses dummy variables for the installed measures to reflect the pre- and post-installation periods; the resulting coefficients reflect the savings for the measures. We estimated program savings from modeled regression coefficients for each measure category. This approach provides the gross savings realized by replacing the customers' existing equipment with new (i.e., rebated) equipment under the program. Savings calculated in this manner were expected to provide an upper boundary to actual savings when the HEHE program is evaluated in comparison to federal efficiency standards, as it is expected that program participants will be replacing older, less-efficient equipment that is likely operating at efficiencies less than federal standards.

The final model specification is:

$$ADCthm_{it} = \gamma_1 ecmfurnXhdd_{it} + \gamma_2 furnXhdd_{it} + \gamma_3 watboilXhdd_{it} + \gamma_4 stmboilXhdd_{it}$$

$$+\gamma_5 tstatXhdd_{it} + \gamma_6 resetcontXhdd_{it} + \gamma_7 sealingXhdd_{it} + \gamma_8 fuelswitchXhdd_{it}$$

$$+ \gamma_9 fuelswitchXpostXhdd_{it} + \beta_1 ecmfurnXpostXhdd_{it} + \beta_2 furnXpostXhdd_{it} + \beta_3 watboilXpostXhdd_{it}$$

$$+\beta_4 stmboilXpostXhdd_{it} + \beta_5 tstatXpostXhdd_{it} + \beta_6 resetcontXpostXhdd_{it} + \beta_7 sealingXpostXhdd_{it}$$

$$+ \beta_8 iwhonlyXpost + \delta_1 hdd_{it} + \tau_{1-6} time_t + \alpha_i + \varepsilon_{it}$$

Where:

$ADCthm_{it}$ = Therms per day used during billing cycle t for customer i (response variable)

hdd_{it} = Average daily heating degree-days for customer t in period I (this accounts for weather-related changes in use). Weather data comes from NOAA NCDC (see section 3.2.1).

$post$ = Binary variable, 1 in the post-period, 0 in the pre-period

$ecmfurn$ = Dummy variable, set to 1 if an efficient furnace with ECM was installed

$furn$ = Dummy variable, set to 1 if an efficient furnace with ECM was installed

$stmboil$ = Dummy variable, set to 1 if an efficient steam boiler was installed

$watboil$ = Dummy variable, set to 1 if an efficient water boiler was installed

$iwhonly$ = Dummy variable, set to 1 if an indirect water heater was installed and the heating system was not replaced

$tstat$ = Dummy variable, set to 1 if a programmable thermostat was installed

$resetcont$ = Dummy variable, set to 1 if a boiler reset control was installed

$sealing$ = Dummy variable, set to 1 if air sealing was installed

$fuelswitch$ = Dummy variable, set to 1 if the billing pattern indicated a fuel switch (the dummy variables for equipment installed in the homes of fuel switch customers were set to 0, so this variable captures all extra use associated with fuel conversions)

$time_t$ = Series of dummy variables reflecting the calendar year, to capture otherwise-unexplained changes over all households in the model during the time period (e.g., changes in natural gas cost)

α_i = The "customer-specific" intercept (or error) for household i, accounting for unexplained differences in baseload natural gas usage between households due to differences in factors such as the number of occupants, appliance holdings, and lifestyles

ε_{it} = Error term that accounts for the difference between the model estimate and actual consumption for household i in period t

The first set of terms in the model above, with coefficients $\gamma_1 - \gamma_7$, are designed to estimate the heating slope for homes with each type of measure installation *throughout* the evaluation period (i.e., the relationship between weather and consumption we'd expect to see among households with each measure category regardless of the period (pre or post)). The coefficients $\gamma_8 - \gamma_9$ are added to capture the extra use that occurred in homes with fuel conversions, (i.e., homes with little or no heating-related use during the pre-installation period and substantial heating use during the post-installation period). Accounting for fuel switches in this way helps ensure that the measure-specific coefficients most accurately reflect the change in consumption associated with these installations.

The second set of terms, with coefficients $\beta_1 - \beta_7$, are used to the estimate the program savings for heating-related measures by capturing the change in the heating slope during the post-period; a dummy variable for each measure category interacts with a weather term and dummy variable, indicating that the month is in the post-period. The final measure-specific coefficient, β_8, is used to estimate the savings from indirect water heaters. As this measure is not heating-related, the *iwhonly* variable is interacted only with the pre-post variable (post). These coefficients are the regression estimators shown in Table A-2.

Weather is represented by average daily heating degree-days in the billing period (i.e., actual weather data). It is included as a stand-alone term to pick up the heating slope for homes without heating system measures, and it is also used as an interaction variable. Finally, we include a series of dummy variables reflecting the time period, to account for widespread changes in consumption that were not related to the program or other known factors.

We considered multiple components for our model specifications as well as performing diagnostics on the models, which we provide in Appendix A.

3.2.3 Engineering Analysis

We used an engineering-based approach to calculate ex post savings for indirect water heaters (IWH). As documented in the DPS-approved work plan, we planned to estimate impacts for IWH installations using billing analysis, but default to engineering analysis if the billing analysis results were not stable or reliable. After reviewing the results from pre/post billing analysis, we decided to pursue the engineering-based approach because the pre/post models were unstable for this measure.[15] We conducted the analysis in two steps:

1. We first estimated ex post savings based on the algorithms in the October 15, 2010 version of the New York Technical Manual (NYTM), incorporating revisions made in the November 26, 2013, Revisions document.
2. We then developed an alternative analysis of savings by applying two recommended adjustments to the NYTM algorithms (based on our engineering review of measure-level savings algorithms) to IWH savings.

Below we describe the methodology used for these two analyses.

Development of Ex Post Savings

To evaluate IWH energy savings, we reviewed the NYTM algorithm for this measure, as well as algorithms from other TRMs and impact evaluations. The NYTM uses the following equation to calculate energy savings from installing indirect hot water heaters.

$$\Delta therms = units\ x\ \left[\frac{GPD\ x\ 365\ x\ 8.3\ x\ \Delta T_w}{100{,}000}\ x\ \left[\frac{1}{E_{t,base}} - \frac{1}{E_{t,ee}}\right] + \left(\frac{UA_{base}}{E_{t,base}} - \frac{UA_{ee}}{E_{t,ee}}\right) x\ \frac{\Delta T_s}{100{,}000}\ x\ 8{,}760\right]$$

[15] This is not uncommon for “base use” measures such as indirect water heaters.

Where;

units – number of high-efficiency water heaters installed under the program

UA_{base} – overall heat loss coefficient of base tank-type water heater (Btu/hr-°F)

UA_{ee} – overall heat loss coefficient of indirect water heater storage tank (Btu/hr-°F)

ΔT_s – temperature difference between the stored hot water and the surrounding air (°F)

GPD – average daily water consumption (gallons/day)

ΔT_w – average difference between the cold inlet temperature and the hot water delivery temperature (°F)

EF_{base} – baseline storage water heater energy factor

$E_{t,ee}$ – energy-efficient indirect water heater boiler combustion efficiency

$E_{t,base}$ – baseline water heater efficiency (RE_{base} if tank type baseline; $E_{c,base}$ if indirect baseline)

RE_{base} – tank-type water heater recovery efficiency

Cap_{base} – tank-type water heater capacity (Btu/hr)

V_{base} – tank-type water heater capacity (gallons)

8.3 – conversion factor (Btu/gallon-°F)

This algorithm is based on the October 15, 2010, version of the NYTM,[16] but incorporates the following revisions made in the November 26, 2013, Revisions document:

1. Applied correct unit conversion factor (Revision Numbers 11-13-2 and 7-13-33)
2. Adjusted formula for EF_{base} from $0.62-0.0019V_{base}$ to $0.67-0.0019V_{base}$ (Revision Number 11-13-2)
3. Revised inlet water temperature for New York City from 62.5°F to 55°F (Revision Number 6-13-1)

[16] New York Department of Public Service's *New York Standard Approach for Estimating Energy Savings from Energy Efficiency Programs,* October 15, 2010, (a.k.a. the New York Technical Manual or NYTM). http://www.dps.ny.gov/TechManualNYRevised10-15-10.pdf.

We re-estimated savings for each IWH in the PA databases, using the revised algorithm as well as unit-specific boiler efficiencies, where available. Where the efficiency of the associated boiler was not available, we used a default value of 90% AFUE.[17] The ex post gross impact analysis thus consists of a simple application of the current NYTM algorithm to tracking data provided by the PAs.

Alternative Analysis: Impact of Recommended NYTM Adjustments

In this alternative analysis, we applied the two recommended adjustments to the NYTM algorithm to the ex post savings values developed above. The two adjustments are:

1. Replacing the overall heat loss coefficient of the base water heater (UA_{base}) assumption in the NYTM with an ASHRAE formula[18] – this adjustment is recommended because the NYTM assumption for UA_{base} is not well documented and is substantially higher than assumption in other sources (including other parts of the NYTM). Ex post savings results are very sensitive to the UA_{base} value.

2. Accounting for summer losses – this adjustment is recommended because during summer months, there is less hot water demand in the home (no hot water is needed for space heating), resulting in decreased load on the boiler. A boiler at part load will typically operate less efficiently than a boiler operating at design load (as demonstrated by boiler efficiency curves). As a result, IWH savings would be overstated in the NYTM algorithm, which assumes a boiler operating at design-load efficiency during summer months.[19]

These two adjustments are described in detail in the NYTM Review section (Section 4.1.6).

3.3 Net Impact Methods

A major objective of this evaluation was to estimate net savings attributable to program activities—that is, the portion of gross energy savings associated with the installation of program-rebated measures that would not have been realized in the absence of the program. The program-induced savings—indicated as a net-to-gross ratio (NTGR)—is made up of free-ridership (FR) and spillover (SO), and is calculated as $(1 - FR + SO)$.

Free-ridership is the portion of the program-achieved verified gross savings that would have been realized absent the program and its interventions. Spillover is generally classified into participant and non-participant spillover. Participant spillover occurs when participants take additional energy-saving actions that are influenced by the program interventions but did not receive program support. Non-participant spillover is the

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[17] The PAs provided boiler efficiencies for 1,803 out of 3,521 rebated IWH installations. PA-provided efficiencies range from 80% AFUE to 98.5% AFUE, with a mean of 90% AFUE. We used these PA-provided efficiencies in this analysis but note that some of the values appear high.

[18] ASHRAE uses: *UAbase = Standby loss / Change in ambient temperature*. Where: *Standby loss* is based on manufacturer data (in Btu/hr); *Change in ambient temperature* is the temperature difference between the stored hot water and the surrounding air (in degrees F).

[19] Summer losses would only apply if an IWH replaces a standard hot water heater, rather than another IWH. Our analysis of IWH savings is based on the assumption that the replaced unit is a standard hot water heater (the existing unit is not tracked by PAs and therefore not available); as a result, summer losses would be applicable to all IWHs included in our analysis.

reduction in energy consumption and/or demand by non-participants because of the influence of the program, despite the fact that they did not participate in it.

As part of this evaluation, we focused on the estimation of free-ridership and participant spillover. Consistent with the approved evaluation plan and primary data collection instruments, we did not assess non-participant spillover, as quantifying market effects was outside the scope of this evaluation[20]. Therefore, the formula we used to calculate the NTGR is:

$$NTGR = 1 - FR + Participant\ Spillover$$

Consistent with established industry practices, we used self-report surveys to estimate free-ridership and spillover. We relied on the participant survey as the primary source for deriving free-ridership estimates, and supplemented them with information from the participating contractor interviews. The participant survey was also the source of participant spillover estimates.

We estimated FR by PA group and by measure. We also developed a program-level FR estimate for each PA. All FR estimates are savings-weighted.[21] We estimated participant spillover by PA, but not by measure.

Table 3-5 below presents the grouping of PAs. The grouping is primarily based on program similarities among the PAs. Specifically, PAs in each group have similar or identical rebated equipment and incentive levels. In addition, the grouping aligns well geographically, with Group 2 being downstate PAs (NY City and Long Island) and Group 3 being primarily upstate PAs.

Table 3-5. PA Groupings

Group	PAs Included
1	National Fuel
2	KEDLI, KEDNY, Con Edison
3	NiMo, Central Hudson, Corning Gas, Enbridge St. Lawrence, O&R

In addition to the quantitative estimate of the NTGR, we developed two additional perspectives on attribution: 1) An independent, quantitative estimate of free-ridership, based on contractor responses to questions about the programs' influence on their equipment sales and recommendations; and 2) a qualitative assessment of attribution, based on research with distributors selling residential gas heating equipment in New York.

The following subsections present a general overview of the methods used in the net impact analysis. Appendix A of this report contains further detail on the NTGR estimation method.

[20] A future comprehensive statewide effort is planned to address non-participant spillover.

[21] We developed savings weights as: *Savings associated with the value to be weighted* divided by *Savings associated with all values to be included in the total*. For example, to determine the PA-level FR value for PA_X and $Measure_Y$, we developed weights for each respondent in PA_X's service territory who installed $Measure_Y$ by dividing the respondent's savings by the sum of savings for all installations of $Measure_Y$ among PA_X's respondents. Similarly, to develop the portfolio-level FR value for PA_Z, we developed weights for each measure offered by PA_Z by dividing the combined savings of the measure by the portfolio savings of PA_Z.

3.3.1 Free-Ridership Methodology

We used telephone interviews with participants to develop the basis of the free-ridership score. We estimated FR by PA group and by measure. We also developed a program-level FR estimate for each PA.

As part of its activity in the market, the program can provide information, training, and other support to contractors, thus potentially influencing the way contractors recommend gas heating equipment to customers. This program outreach and the interactions with contractors might not necessarily be visible to program participants. As such, FR estimates based only on participant feedback might not accurately reflect the full credit that the program deserves. To address this gap, telephone interviews with trade allies were used to adjust the participant-derived FR rates to account for the indirect influence (via contractors) of the program on participants.

Participant Free-Ridership Score

We base the free ridership score on a series of questions in the participant survey, designed to gather data on the customer's preexisting plans to implement the program measure, willingness to have bought the measure even if there was no program incentive (i.e., to pay full cost), and likelihood of taking the same action in the absence of the program.

The survey measured three distinct areas of program influence:

- Program influence on the efficiency of the installed equipment (EI)
  - Influence of individual program components (marketing and incentives) on the decision to install high-efficiency heating equipment
  - Likelihood to install the same efficiency equipment absent the incentives
- Program influence on timing of the equipment installation (TI)
- Program influence on quantity of the equipment installation (QI)

Efficiency (EI), timing (TI), and quantity (QI) of the installation are distinct avenues of program influence. However, the timing of the installation and quantity of measures installed are conditional on efficiency. The program can only realize timing savings if the customer would have installed the efficient equipment on their own, but the program caused the installation to happen earlier. Similarly, savings due to a quantity increase can only happen if a customer who was already installing some energy-efficient measures chooses to install additional measures because of the program.[22] This approach to free-ridership was discussed with and approved by the DPS and is consistent with approaches approved by the DPS in the past.

We believe that when the three concepts are measured as distinct yet conditional methods of program influence, it is appropriate to account for each one. Multiplication and averaging are appropriate approaches to achieve that. To arrive at the free-ridership score, we will combine the EI and QI scores multiplicatively. We will then average this product with the TI score, but only in cases when the timing score does not exceed the product of multiplying the EI and QI scores. In cases where the timing score exceeds the product of EI and QI,

[22] Because the amount of duct and air sealing is not easily quantifiable for respondents, the free-ridership algorithm omits the quantity component for this measure.

the FR rate is based on just the product of the EI and QI scores. This selective averaging is important so the program is not penalized for having a smaller influence on the timing of the purchase than the efficiency and size of the purchase. In addition, the timing and quantity scores will only be included in the algorithm if EI ≥ 0.50 (i.e., there is a reasonable likelihood that high-efficiency equipment would have been installed in the absence of the program).

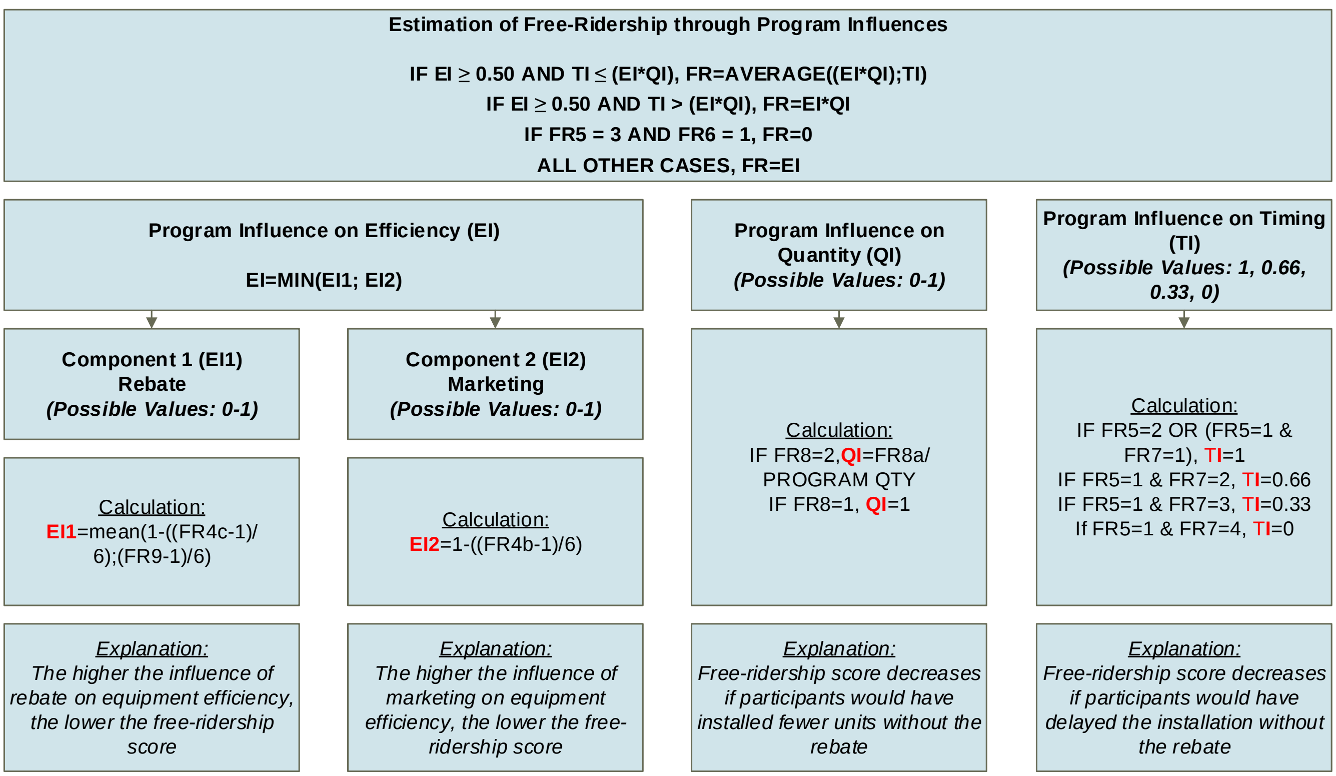
$$IF\ EI \geq 0.50\ AND\ TI \leq (EI*QI),\ THEN\ FR = AVERAGE((EI*QI);TI)$$

$$IF\ EI \geq 0.50\ AND\ TI > (EI*QI),\ THEN\ FR = EI*QI$$

$$ALL\ OTHER\ CASES,\ FR = EI$$

Figure 3-3 below provides a visual depiction of the FR algorithm for heating system measures (furnaces, boilers, and indirect water heaters).

Figure 3-3. Overview of the Participant Free-Ridership Approach



Free-Ridership Adjustment through Contractor Research

The evaluation team used interviews with participating contractors to determine if the program had any influence on contractor recommendations of high-efficiency equipment. As part of the interviews, contractors were asked a series of questions about their knowledge and interactions with the program, program influence on their stocking and sales practices, and the customer decision-making process. Based on the trade ally responses, a participant FR score adjustment factor was calculated and applied to arrive at the final FR rate.

The analysis used the following three steps:

1. **Determining the trade ally attribution score.** We used participant survey results to determine the contractor's attribution score. While participants are unlikely to be aware of the program's influence on their contractor, they can fairly easily estimate and report their contractor's influence on their decision to install high-efficiency gas heating equipment. Participants were asked to rate the influence of their contractor's recommendations on their decision to install high-efficiency equipment.[23] FR scores of participants who were heavily influenced by trade ally recommendations were set to 0, giving the program full credit for the project. The evaluation team then recalculated a FR score using these adjusted values. This maximum trade ally-adjusted FR score effectively represents the maximum possible attribution that the program can claim, and assumes that every contractor was heavily influenced by the program in how they approach the recommendations and sales of the heating equipment. The differential between the two scores (i.e., the unadjusted participant FR score and the participant FR score adjusted for contractor influence) is the contractor attribution score, or the maximum possible decrease in the participant FR score due to program influence on contractor recommendations that the program can claim.

2. **Determining the influence of the program on participating contractors.** Although the program attempts to get contractors to recommend more energy efficiency equipment, a number of factors influence contractor recommendations. Therefore, only a portion of the contractor attribution score is due to the program influence on contractor recommendations. We used the results of the contractor interviews to determine the percentage of the contractor attribution score the program truly deserves. Contractors were asked questions about changes in their knowledge of high-efficiency options, their comfort level with recommending the high-efficiency options, how frequently they recommend high-efficiency equipment options, and their estimated degree of program influence on each of those areas. For each contractor, we developed a contractor program influence score. A detailed description of how the contractor program influence score was developed can be found in Appendix A - Determining the Influence of the Program on Participating Contractors.

3. **Determining the FR adjustment score and the final FR score.** We combined the influence of the contractors on participants and the influence of the program on contractors to arrive at the FR adjustment score. We then applied the adjustment score to the participant FR scores to arrive at the final FR rate.

3.3.2 Spillover Methodology

We assessed participant spillover through the participant survey by asking about efficiency actions customers took as a result of participating in the program, but for which they did not receive an incentive. The survey instrument contained checks to ensure consistency of response.

The HEHE program generally has not had a substantial marketing component that would promote energy efficiency in general, or the installation of other measures aside from the ones rebated through the program. However, experience suggests that, for some, the experience of using one type of energy-efficient equipment can lead to looking for other ways to make one's home more energy-efficient. If program-induced, those additional improvements can result in spillover savings that the program can claim. As part of the participant survey, the evaluation team investigated whether participant spillover existed, and in cases where it existed, quantified it.

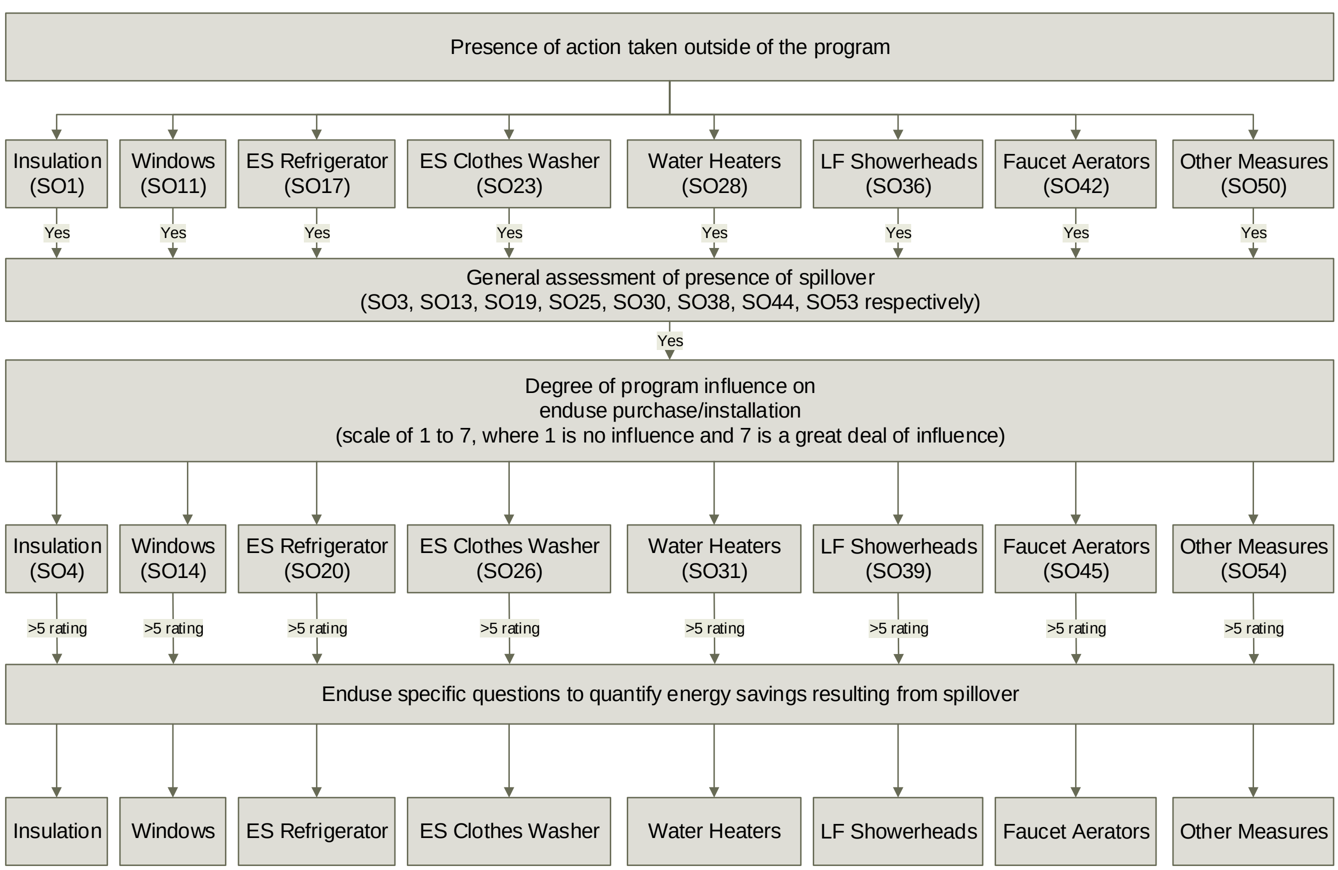
[23] Participants were asked to provide a rating on a scale of 1 to 7, where 1 is "not at all influential" and 7 is "very influential."

Participant spillover can result from a variety of measures. To limit survey length, participants who indicated having taken additional energy-saving actions were asked about a list of measures that could reasonably be expected to be influenced by program participation. This list included insulation, windows, ENERGY STAR® refrigerators, ENERGY STAR® clothes washers, water heaters, low-flow showerheads, and faucet aerators. In addition, participants were asked about any other measures they might have installed without program support. For measures that participants identified as having implemented, the survey then asked several follow-up questions:

1. Did the program influenced their actions, and if so, to what degree of influence?
2. If respondents reported that the program had influenced their decision (a rating of 6 or 7 on a scale from 1 to 7), they were also asked:
    a. To explain how the program influenced their decision to make specific additional improvements
    b. A few measure-specific questions about the characteristics of the installed measure

Figure 3-4 below provides a graphical depiction of the participant spillover approach.

Figure 3-4. Overview of the Participant Spillover Approach



For each measure identified as participant spillover, we quantified savings using the responses to enduse-specific survey questions as well as engineering assumptions. For each PA, participant spillover was calculated by dividing the estimated spillover savings of survey respondents by the respondents' ex post gross program impacts, as follows:

$$\text{Participant Spillover Rate}_{PA} = \frac{\text{Net Participant Spillover}_{PA}}{\text{Ex Post Gross Program Impacts}_{PA}}$$

The participant spillover analysis was conducted using the *standard* level of methodological rigor. Per DPS guidelines,[24] the magnitude of expected spillover savings is the primary determinant of the level of rigor, and we expected participant spillover from the HEHE program to be small.

3.3.3 Distributor Perspective on Attribution

In addition to the NTGR estimation approach described above, we conducted research with New York distributors of residential gas heating equipment, aimed at obtaining an alternative estimate of attribution. This task was intended as a supplemental analysis. Because this analysis explores market effects (which are beyond the scope of our quantitative estimate of the NTGR), the results from this research were not meant to be combined with other results from this evaluation.

The distributor analysis is based on seven completed in-depth interviews with distributors.[25] The interviews focused on the impacts that the New York residential gas heating programs have had on 1) the distributors' overall sales volume, and 2) the efficiency of the major residential gas heating equipment they sell (furnaces, water boilers, steam boilers, and indirect water heaters). While we attempted to obtain quantitative estimates of the effects of the HEHE Programs on distributors' sales, distributors were unable or unwilling to provide us with the requested information. As a result, the findings of this analysis are qualitative.

3.4 Incremental Cost Methods

The objective of incremental measure cost analysis was to update current incremental cost values for potential future use in cost-effectiveness tests. We estimated incremental costs for the four major measures offered through the programs: furnaces, water boilers, steam boilers, and indirect water heaters.

The incremental measure cost analysis consisted of four steps:

1. Determine the efficiency levels for baseline and rebated equipment for each of the four measures, through review of the NYTM and program-tracking data.[26]

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[24] See Appendix F (*Program-Level Participant and Nonparticipant Spillover Guidance*) of the *Evaluation Plan Guidance for EEPS Program Administrators* (Update #4-August 2013).

[25] We called and attempted to complete an interview with each of the 68 New York distributors for whom we had contact information, (census attempt).

[26] We did not include capacity considerations in this analysis as it would have unduly increased respondent burden.

2. Review incremental cost values currently used by the PAs and secondary sources (e.g., RSMeans Labor Costs).
3. Conduct a telephone survey with contractors to determine the total installed costs (costs of equipment, labor, and installation materials) associated with baseline and high-efficiency measures.
4. Develop new incremental cost values by aggregating contractor responses and compare them to values currently used by PAs.

The incremental cost analysis is based on telephone interviews with participating contractors. We asked these contractors a series of questions to determine the total installed cost to a consumer of various efficiency levels of a given measure. We asked each contractor questions about a) the baseline efficiency measure and b) one or more levels of high efficiency equipment rebated by the programs. Table 3-6 shows the baseline efficiencies as well as the rebate-eligible efficiency levels included in the survey.

Table 3-6. Baseline Efficiency Levels by Measure

Measure	Baseline Efficiency Level	Rebate-Eligible Efficiency Levels
Furnace	78% AFUE	90%, 92%, 94%, 95% AFUE
Water Boiler	80% AFUE	85%, 90% AFUE
Steam Boiler	75% AFUE	82% AFUE[a]
Indirect Water Heater	53% EF storage unit	n/a

[a] National Fuel also offers a rebate for steam boilers with 81% AFUE.

For example, for furnaces, we asked the following question:

IC1. What is the cost to a typical customer to install a furnace rated at… AFUE? Please consider the entire cost to a typical customer, including labor, cost of the equipment, and cost of any associated materials.

a. 78%
b. 90%
c. 92%
d. 94%
e. 95%

Following data collection, we first cleaned survey responses by dropping responses that are 1) internally inconsistent, i.e., the contractor provided a lower cost estimate for a higher level of efficiency for a given measure; and 2) outlier responses, i.e., cost estimates that were substantially outside the range of responses provided by other contractors. Overall, we dropped between 7% and 25% of responses due to these data issues.

Table 3-7 shows the number of responses received from contractors, for each measure and efficiency level, and the number excluded from our analysis.

Table 3-7. Summary of Dropped Responses

Measure	Total Responses	Responses Dropped
Furnace – 78% AFUE	49	12
Furnace – 90% AFUE	59	13
Furnace – 92% AFUE	55	14
Furnace – 94% AFUE	46	11
Furnace – 95% AFUE	65	9
Water Boiler – 80% AFUE	28	3
Water Boiler – 85% AFUE	29	4
Water Boiler – 90% AFUE	24	2
Steam Boiler – 75% AFUE	28	2
Steam Boiler – 82% AFUE	38	3
0.53 EF Storage	35	3
Indirect Water Heater	36	3

We used the remaining survey responses to calculate incremental cost using two different methodologies:

1. Approach #1: We first calculated the mean and median installed cost for each efficiency level of a given measure. We then determined incremental cost by subtracting the mean (and median) installed cost of the standard efficiency equipment from the mean (and median) installed cost of the efficient equipment. We did this for each level of high efficiency for a given measure.
2. Approach #2: We first calculated incremental costs for each contractor and each efficiency level by subtracting the reported installed cost of the standard efficiency unit from the reported installed cost for the higher efficiency unit. We then combined the contractor-level results to develop statewide incremental cost statistics (minimum, maximum, mean, and median) for each rebate-eligible efficiency level.

By first estimating mean installed costs for each efficiency level, our first approach used all valid contractor responses, even if a contractor was only able to provide an estimate for a single efficiency level. While this approach allowed us to utilize the maximum number of responses, it led, in the case of furnaces, to internal inconsistencies in our incremental cost estimates.[27]

In contrast, by first estimating each contractor's incremental cost for each reported efficiency level, our second approach only utilized responses from contractors who were able to provide installed costs for standard efficiency equipment. This approach solved the issue of internal inconsistency, and it has the additional advantage of producing a minimum and a maximum incremental cost value for each level of high efficiency

[27] A substantial number of contractors reported costs for furnaces of 95% AFUE but did not report costs for furnaces of 94% AFUE. These contractors, on average, reported lower costs for 95% AFUE units than were reported for 94% AFUE units. As a result, the overall reported average cost for 95% AFUE units was lower than that for 94% AFUE units, leading to lower incremental cost estimates for 95% AFUE units compared to 94% AFUE units.

for a given measure. However, it has the disadvantage of utilizing fewer responses and systematically excluding responses from contractors who do not install standard efficiency equipment (or could not provide a cost estimate for it).

Weighting

We weighted contractor responses by region (upstate versus downstate) to account for differences in the geographic distribution of contractors responding to the survey compared to contractors in the population. Table 3-8 presents the contractor weights, estimated by dividing the percentage of contractors in the population by the percentage of contractors in the sample, for each region.

Table 3-8. Contractor Weighting for Incremental Cost Analysis

Measure	% of Contractors in Population		Percentage of Contractors in Sample		Resulting Weight	
	Upstate	Downstate	Upstate	Downstate	Upstate	Downstate
Furnace	85%	15%	90%	10%	0.94	1.50
Water Boiler	67%	33%	54%	46%	1.25	0.71
Steam Boiler	27%	73%	62%	38%	0.43	1.94
Indirect Water Heater	54%	46%	73%	27%	0.75	1.68

Precision

Because we attempted to reach every contractor in our sample frame, there is no sampling error associated with our estimates of incremental costs.

4. Results

This section presents the results from the different components of this evaluation: NYTM review, gross and net impact analyses, and incremental cost analysis.

4.1 New York Technical Manual Review

The consolidated *New York Standard Approach for Estimating Energy Savings from Energy Efficiency Programs* (NYTM) was initially issued in October, 2010. As part of this evaluation, the program administrators (PAs) requested that the evaluation team review the current algorithms within the NYTM (including revisions through November 23, 2013) and provide comments on whether the algorithms are robust as shown, or if, in our best judgment, changes to the algorithms should be submitted to the DPS for consideration. We arrived at our conclusions through comparing the algorithms within the NYTM to algorithms in other TRMs. Additionally, we had the opportunity to compare the engineering results to actual results from the billing analysis we performed.[28]

We reviewed seven different gas measures included within the HEHE Program, as well as EC motors, a related measure impacting electric usage. For each measure, we describe the measure, show the NYTM algorithm, provide our comments on each algorithm, and, as needed, suggest changes for the DPS to consider.

Generally, we find that the NYTM's algorithms accurately represent the measures they describe. We believe the only major exceptions to this finding are that 1) the FLH values recommended by the NYTM appear to be significantly overstated, and 2) the energy savings factor (ESF) values for programmable thermostats may be overstated. If these values are updated to more appropriate values, we believe the NYTM algorithms will more accurately represent the savings from the measures they describe. Other findings and recommendations for consideration would only have a minor effect on overall program savings.[29]

The following subsections present our findings for each reviewed measure. Measures are discussed in alphabetical order. Measure findings are summarized in Table 4-1 below.

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[28] It should be noted that over the course of the evaluation period, the NYTM underwent numerous revisions. The implementation of the NYTM and its revisions varied by PA. In some cases, differences between ex ante and ex post savings values are the result of revisions to the NYTM and when PAs implemented these revisions.

[29] Specifically, we note questions about the algorithm for indirect water heaters and the deemed savings value provided for EC motors on furnace fans. However, given their low contribution to program savings, these issues have a relatively minor effect overall.

Table 4-1. Summary of NYTM Review Findings and Recommendations

Measure	Key Findings	Recommendations
Air Sealing	■ Algorithm generally represents savings well	■ Calibrate model used in alternate algorithm ■ Clarify the term incorporating heating and distribution system efficiency
Boilers & Furnaces	■ Algorithm well specified ■ Algorithm overstates savings with default inputs due to high NYTM FLH assumptions	■ Update NYTM FLH assumptions using findings from billing analysis
Boiler Reset Controls	■ Algorithm well specified ■ Algorithm overstates savings with default inputs due to high NYTM FLH assumptions	■ Clarify the "units" variable to reflect that savings for only one control can be claimed for each boiler in the residential sector. ■ Update NYTM FLH assumptions using findings from billing analysis
Duct Sealing	■ Algorithm generally represents savings well ■ Algorithm does not incorporate interactive effects from furnace efficiency	■ Include a term in algorithm to account for furnace efficiency and interactive effects.
EC Motors	■ Deemed value seems high and is not NY-specific	■ Conduct additional research to update NYTM deemed value
Indirect Water Heaters	■ Algorithm well specified ■ UA_{Base} inputs to algorithm not well documented ■ Algorithm does not account for summer losses	■ Update NYTM to document UA_{Base} input assumptions; alternatively consider using ASHRAE formula ■ Add term to NYTM algorithm to account for summer losses
Programmable Thermostats	■ Algorithm in line with those used in other TRMs ■ Nevertheless, we believe algorithm overstates savings ■ Backed up by billing analysis	■ Conduct additional research to determine appropriate choice of ESF for NY

4.1.1 Air Sealing

NYTM Description

Air Leakage Sealing

Reduction in the natural infiltration rate of the home through sealing air leaks in the building envelope. These algorithms are used for single family and smaller multi-family buildings where the use of a blower door is feasible. An alternate method for estimating savings is based on the building's heated square footage and is also provided for larger multi-family buildings.[30]

NYTM Algorithm

The NYTM contains two algorithms for use, one that uses inputs from a blower door test and one that does not. Both are shown next.

$$\Delta therms = \frac{\Delta CFM_{50}}{n - factor}\ x\ \frac{\Delta therm}{CFM}\ x\ \frac{AFUE_{base}}{AFUE_{part}}\ x\ \left[\frac{\eta_{dist,base}}{\eta_{dist,part}}\right]_{heat}$$

or

$$\Delta therms = Floor\ area\ \left(1000\ SF\right)\ x\ (\frac{\Delta therms}{1000}SF)$$

Algorithm Inputs

ΔCFM50 – change in infiltration rate (cfm) at measured 50 Pa

n-factor – correction from CFM50 to natural infiltration rate

Δtherm/1000 SF – gas consumption impact per CFM of infiltration reduction based on prototypical simulation

Δtherm/CFM – gas consumption impact per CFM of infiltration reduction based on prototypical simulation

$AFUE_{base}$ – AFUE used in the simulations

$AFUE_{part}$ – AFUE of heating system within participant population

$\eta_{dist,base}$ – distribution system seasonal efficiency used in simulations

$\eta_{dist,part}$ – distribution system seasonal efficiency within participant population

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[30] New York Department of Public Service's *New York Standard Approach for Estimating Energy Savings from Energy Efficiency Programs,* October 15, 2010, (a.k.a. the New York Technical Manual or NYTM). http://www.dps.ny.gov/TechManualNYRevised10-15-10.pdf, page 33.

Comments

The NYTM provides algorithms for savings during both heating season (gas heating) and cooling season (air conditioning). We reviewed only the algorithms applicable for heating season.

The second algorithm uses variables from a prototype. This type of approach typically provides savings that are reasonable if the prototype has been calibrated. From our review of the prototypes within the NYTM, this does not appear to have occurred, and therefore the values within the NYTM may be biased either high or low.

Our billing analysis indicated a realization rate of 93.3% for this measure, indicating that the algorithm being used appears to be a good estimate of actual savings.

Suggested Changes

We suggest the NYTM text be clarified to more clearly explain the term for duct and furnace efficiency factors incorporated in the blower door algorithm, which is unclear in the current version of the NYTM. Otherwise, we believe that the blower door NYTM algorithm is well specified, and if this term is treated correctly, will provide good estimates of savings. We also suggest that the models used to define a term used in the alternate algorithm be calibrated in order to provide better estimates of savings.

4.1.2 Boilers and Furnaces

NYTM Description

Boilers

High efficiency condensing and non-condensing hot water and steam boilers in single family and multi-family buildings.[31]

High Efficiency Gas Furnaces

High efficiency condensing gas furnaces with an AFUE > 92% in single family and multi-family applications.[32]

NYTM Algorithm

$$\Delta therms = units\ x\ \frac{kBtuh_{in}}{unit}\ \mathrm{x}\ \left(\frac{\eta_{ee}}{\eta_{base}}\ -1\right)\ \mathrm{x}\ \frac{EFLH_{heat}}{100}$$

Algorithm Inputs

units – number of heating units installed under program

$kBtuh_{in}$/unit – nominal heating input capacity per unit in kBtuh/hr

[31] Ibid., page 48.

[32] Ibid., page 69.

η_{ee} – unit efficiency

η_{base} – baseline efficiency

$EFLH_{heat}$ – heating equivalent full-load hours

Comments

The NYTM algorithms for boilers and furnaces are identical, with the exception of choice of default input values and specifications for use. This aligns closely with both the Illinois and Mid-Atlantic TRMs, which similarly use identical algorithm specifications for boilers and furnaces.

For boilers, the NYTM allows the η_{ee} and η_{base} terms (unit efficiency and baseline efficiency, respectively) to be inputted as either AFUE ratings (boilers under 300 kBtu/hr) or thermal or combustion efficiency ratings, for boilers larger than 300 kBtu/hr. In the context of this evaluation, we reviewed this algorithm only for residential-sized boilers, under 300 kBtu/hr.

For furnaces, the NYTM specifies the algorithm for only AFUE ratings, and defines the algorithm as being applicable for furnaces of 92% AFUE and up. The PAs appear to use this algorithm for furnaces of 90% AFUE as well. All PAs rebate furnaces of 90% AFUE through the Programs, as well as additional higher levels of efficiency. The PAs who provided us information on how savings were calculated for their databases indicated that they use the NYTM High Efficiency Gas Furnaces algorithm to calculate these savings. Those who did not utilize the algorithm, appear to have savings closely in line with this formula.

We find the algorithm to be reasonable and comparable to those used elsewhere, but our billing analysis indicates that, if using NYTM default assumptions, the engineering algorithm overestimates savings. This overstatement can be attributed to NYTM default FLH values considerably higher than those produced in our billing analysis.

Suggested Changes

We suggest revising the algorithm description for furnaces to apply to furnaces of 90% AFUE and up, as New York PAs routinely incent and claim savings for furnaces of 90% AFUE. Given that an identical formula is used for boilers of 85% AFUE and higher, we do not see any misspecification for the algorithm for furnaces in this AFUE range. Additionally, to better align future estimates of savings with actual values, we suggest the NYTM estimates of full-load hours be updated in accordance with this study, which will reduce expected savings to better align with the results of this billing analysis. This recommendation is detailed in further in Section 4.2.1.

4.1.3 Boiler Reset Controls

NYTM Description

Boiler Reset Controls

Reset of hot water setpoint in single and multi-family residential buildings with zone thermostat control. The measure is assumed to be applied to existing non-condensing boiler systems.[33]

[33] Ibid, page 50.

NYTM Algorithm

$$\Delta therms = units\ x\ \frac{kBtuh_{in}}{unit}\ x\ \frac{EFLH}{100}\ x\ ESF$$

Algorithm Inputs

units – number of boiler reset controls installed

$kBtuh_{in}/unit$ – input capacity of system served by boiler reset control

$EFLH_{heat}$ – heating equivalent full load hours

ESF_{heat} – energy savings factor

Comments

The NYTM algorithm for boiler reset control savings operates similarly to the algorithm for programmable thermostats discussed later in this section, and roughly defines boiler reset control savings as an energy-savings factor multiplied by annual heating equipment load. None of the other TRMs we reviewed specified algorithms for boiler reset control savings, but we are nevertheless comfortable with the methodology of the algorithm, with one exception: the algorithm assumes that multiple controls would increase the savings of a single boiler.[34] While different controls in commercial applications can control different systems, it is unclear how additional controls would provide additional savings for residential applications when the customer has only one boiler.

Inputs to the algorithm are simple and well defined, and default values suggested for heating unit capacity when customer-specific data are not available are reasonable, with the exception of overstated FLH values, discussed in the boiler & furnace algorithm section.

The major variable in the algorithm other than heating load hours and heating system size is the choice of Energy Savings Factor (ESF). The NYTM uses a value of 5.0%, suggested by the Energy Solutions Center. While we do not have another TRM value to reference, the Massachusetts TRM specifies a deemed savings value of 7.9 MMBtu/reset control, which aligns closely with the NYTM algorithm if reasonable default values are chosen, implying a similar ESF.

While our billing analysis shows that slightly less than two-thirds of expected savings from these algorithms are actually being realized by customers, the percentage savings observed in billing analysis is actually in line with the NYTM assumption of a 5.0% ESF, suggesting that other parts of the algorithm are responsible for overstating savings relative to observed savings. We attribute this overstatement to the NYTM FLH values significantly larger than those estimated in this study. If the FLH estimates for furnaces and boilers are revised downward based on this evaluation, that change would bring boiler reset control savings estimated by the NYTM algorithm into better alignment with billing analysis results.

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[34] During the DPS review process, the TecMarket team clarified that the "units" term in the boiler reset control algorithm refers to the number of controllers installed by the program. The evaluation team has added a recommendation that this be clarified in future versions of the Tech Manual.

Suggested Changes

Remove the units variable and assume that a single control is used for a single boiler in the residential sector. Additionally, to better align future estimates of savings with actual values, we suggest the NYTM estimates of full-load hours be updated in accordance with this study, which will reduce expected savings to better align with the results of this billing analysis. This recommendation is detailed in further in Section 4.2.1.

However, if FLH values are not updated, we suggest additional research to verify ESF values could be valuable.

4.1.4 Duct Sealing

NYTM Description

Duct Insulation and Leakage Sealing

Improvements to duct systems made separately or in conjunction with a high efficiency furnace, heat pump, or air conditioner installation.[35]

NYTM Algorithm

$$\Delta therms = units\ x\ \frac{kBtuh_{in}}{unit}\ x\ \frac{EFLH_{heat}}{100}\ x\ \left[1 - \frac{\eta_{dist,base}}{\eta_{dist,ee}}\right]_{heat}$$

Algorithm Inputs

Δ therms – gross annual gas savings

$kBtuh_{in}/unit$ – the nominal input rating of the heating capacity of the furnace

$EFLH_{heat}$ – heating equivalent full-load hours

100 – conversion factor (kBtuh/therm)

$\eta_{dist,base}$ – statewide cooling average for uninsulated duct with 20% leakage

$\eta_{dist,ee}$ – distribution system seasonal efficiency within participant population

Comments

The NYTM specifies therm savings for duct insulation and leakage that incorporates system distribution efficiency, but not furnace efficiency.

The NYTM algorithm is relatively similar to those used in the Mid-Atlantic and Illinois TRMs and, given default assumptions, produces similar but slightly higher savings. We attribute this to the inclusion of a term representing furnace efficiency in the similar algorithm in the Mid-Atlantic and Illinois TRMs, which the NYTM does not contain. This term accounts for the interactive effects between distribution system efficiency and

[35] Ibid., page 71.

furnace efficiency. While the difference in savings produced by the addition of this term will be minor, accounting for furnace efficiency will more accurately account for savings produced by duct sealing. Overall heating performance is affected by both heating system distribution efficiency and furnace efficiency. If the same improvement to distribution system efficiency is made in identical homes, one with a very high efficiency furnace and one with a baseline efficiency furnace, smaller savings will be realized in the home with a high efficiency furnace. Because this term is not included, this difference in savings is not captured.

The Mid-Atlantic and Illinois TRMs also contain alternative algorithms for estimation of duct insulation and leakage sealing savings, using modified blower door subtraction to determine the duct leakage rate, rather than using system distribution efficiency.

Suggested Changes

We suggest considering an update to the NYTM algorithm to include a term covering furnace efficiency, to account for interactive effects between furnace efficiency and distribution system efficiency. Inclusion of algorithms to calculate savings with a duct leakage rate determined through modified blower door subtraction could also be considered.

4.1.5 EC Motors

NYTM Description

EC Motors on Furnace Fans

This section covers the electricity savings associated with electronically commutated (EC) motors used on gas furnace supply fans. Energy and demand saving are realized through reductions in fan power due to improved motor efficiency and variable flow operation. Note: Some homeowners may elect to run their furnace fan continuously to improve air quality and equalize temperatures in the home. This behavior may *increase* energy consumption over a standard furnace fan that operates only on a call for heating. The unit savings number accounts for this effect by reducing the EC motor savings to account for the fraction of homeowners who operate their systems in this manner.[36]

NYTM Deemed Values

$$Electricity\ Impact\ (kWh) = 733\ kWh/furnace$$

$$Demand\ Impact\ (kW) = 0\ kW/furnace$$

Comments

[36] Ibid., page 65.

The NYTM includes a deemed kWh savings value, originally estimated by the State of Wisconsin Public Service Commission for new EC motors installed in Wisconsin.[37] That report builds on a previous study[38] that performed field monitoring on 31 new furnaces installed across Wisconsin. These studies take into account the following parameters associated with the installation of an EC motor on a furnace:

- Full-load hours (FLH) during heating and cooling seasons
- Changes in energy consumption across the heating, cooling, and shoulder seasons
- Differences in operations of EC motors before and after installation[39]
- Additional energy used by EC motors in standby mode[40]
- Reduced waste heat from EC motors (this results in an energy penalty during the heating season, and an energy savings during the cooling season)
- Homes with and without central air conditioning systems

The studies performed by the State of Wisconsin analyze the above parameters through field monitoring of installed systems, and 232 interviews of homeowners to assess operations. While these parameters may not accurately reflect operations of an EC motor operating in New York (e.g., FLH will be different), they establish a model framework for assessing the impacts of EC motors. Also notable is the inclusion of cooling season savings in the Wisconsin deemed savings value.

Other TRMs appear to use significantly lower deemed savings; the Mid-Atlantic, Illinois, and Massachusetts TRMs use savings of 241 kWh, 418 kWh, and 600 kWh per furnace, respectively. Climate zone differences likely account for part of the differences across the TRMs, but the other differences in the deemed values are not immediately evident.

Suggested Changes

The analysis performed by the Wisconsin studies established a thorough framework for determining savings impacts for EC motors. Currently, we do not have enough NY-specific data to accurately adjust the NYTM deemed value.[41] We recommend that additional, New York specific, research be performed into the

[37] State of Wisconsin Public Service Commission. Focus on Energy Evaluation – ECM Furnace Impact Assessment Report. January 12, 2009.

[38] State of Wisconsin Department of Administration Division of Energy. Residential Programs. Electricity Use by New Furnaces. A Wisconsin Field Study. October 2003.

[39] The study analyzed differences in energy consumption associated with homeowners that operate their fans in auto, continuous or sporadic (i.e., a combination of auto and continuous) operation. The study compared before and after practices in order to more accurately quantify savings resulting from the EC motor.

[40] According to the study, EC motors use 30 kWh more per year than standard furnace motors when operating in standby mode.

[41] The full-load hour data that we do have for NY PAs averages to approximately 940 hours during the heating season (we did not have data for the cooling season). The Wisconsin study used 1,000 hours for the heating season and 400 hours for the cooling season.

parameters listed above to more accurately quantify savings for the state of New York. Notably, while the value reported by the Wisconsin studies likely accurately represents savings accurately for Wisconsin program participants, the evaluation incidence of central cooling systems for participants in New York is lower than that in Wisconsin. RECS data indicates that penetration of this equipment is substantially higher in Wisconsin than in the Northeast – over 60% of homes in Wisconsin are indicated to have central air conditioning, compared to just over 20% of homes in New York.[42] As such, the Wisconsin deemed value, including cooling season savings, likely overstates savings achieved by installation of EC motors on furnaces in New York.

4.1.6 Indirect Water Heaters

NYTM Description

Indirect Water Heaters

Indirect water heaters are tank-type water heaters that are indirectly heated by hot water from a boiler rather than direct input from electric elements or gas burners. A heat exchanger separates the potable water in the water heater from the boiler water. The baseline assumption for indirect water heaters is a standard efficiency tank type water heater or an indirect system with a standard efficiency boiler.[43]

NYTM Algorithms

$$\Delta therms = units\ x\ \left[\frac{GPD\ x\ 365\ x\ 8.3\ x\ \Delta T_w}{100{,}000}\ x\ \left[\frac{1}{E_{t,base}} - \frac{1}{E_{t,ee}}\right] + \left(\frac{UA_{base}}{E_{t,base}} - \frac{UA_{ee}}{E_{t,ee}}\right) x\ \frac{\Delta T_s}{100{,}000}\ x\ 8{,}760\right]$$

$$UA_{base} = \frac{\frac{1}{EF_{base}} - \frac{1}{RE_{base}}}{67.5\ x\ (0.000584 - \frac{1}{RE_{base}\ x\ Cap_{base}})}$$

Algorithm Inputs

units – number of high-efficiency water heaters installed under the program

UA_{base} – overall heat loss coefficient of base tank-type water heater (Btu/hr-°F)

UA_{ee} – overall heat loss coefficient of indirect water heater storage tank (Btu/hr-°F)

ΔT_s – temperature difference between the stored hot water and the surrounding air (°F)

GPD – average daily water consumption (gallons/day)

Because the heating FLH value was the only PA-specific number we had and it was relatively close to the Wisconsin number, we decided not to make any adjustments.

[42] Residential Energy Consumption Survey (RECS). U.S. Energy Information Administration (August, 2011).

[43] New York Department of Public Service, page 84.

ΔT_w – average difference between the cold inlet temperature and the hot water delivery temperature (°F)

EF_{base} – baseline storage water heater energy factor

$E_{t,ee}$ – energy-efficient indirect water heater boiler combustion efficiency

$E_{t,base}$ – baseline water heater efficiency (RE_{base} if tank type baseline; $E_{c,base}$ if indirect baseline)

RE_{base} – tank-type water heater recovery efficiency

Cap_{base} – tank-type water heater capacity (Btu/hr)

V_{base} – tank-type water heater capacity (gallons)

8.3 – conversion factor (Btu/gallon-°F)

Comments

To evaluate IWH energy savings, we reviewed the NYTM algorithm for this measure as well as information from other TRMs. Because we were unable to find algorithms in other TRMs (the Massachusetts TRM contained only a deemed savings value), we also looked at impact evaluations, including the Massachusetts Home Energy Services Impact Evaluation.[44]

The NYTM provides inputs to several variables, and a separate equation for calculating UA_{base}. The NYTM provides inputs to the variables in the UA_{base} equation, but does not provide a reference for the hard-coded values (i.e., 67.5 and 0.000584). UA_{base} is one of the most sensitive inputs to the analysis, and varies significantly across TRM references:

- Using the NYTM algorithm and default inputs yields a UA_{base} value of 9.42 Btu/hr-°F.
- Per NYTM Record of Revision Number 7-13-6, the UA_{base} default value for a typical 40 gallon gas water heater is 13.6.
- The NYTM UA_{base} default value for hot water tank insulation for a 40 gallon water heater is 4.58.
- The *Massachusetts Home Energy Services Impact Evaluation Method* uses a UA_{base} value of 2.38.

This input (UA_{base}) is of some concern, as its value in different NYTM sections is extremely variable (for what appear to be the same baseline systems) and the final calculated savings for indirect water heaters using the NYTM are very sensitive to this equation. Otherwise, we feel that the inputs to the NYTM algorithm are reasonable and appropriate in the revised version of the NYTM.

The Massachusetts Home Energy Evaluation (MA Method) uses a similar equation to determine energy savings from installing indirect hot water heaters, but also subtracts energy efficiency losses from operating the system in the summer months, when the space-heating boiler being leveraged to also heat water is not operating at design load. The overall formula is:

[44] Final Home Energy Services Impact Evaluation, August 2012. http://www.ma-eac.org/Docs/8.1_EMV%20Page/2012/2012%20Residential%20Studies/MA%20RRLI%20-%20Home%20Energy%20Services%20%202011%20Impact%20Evaluation%20Report_FINAL_04SEPT2012.pdf.

Total Savings = Standby Savings + Efficiency Savings – Summer Losses

$$Standby\ Save, MMBtu = \Delta T_{tank,ambient} \times 8{,}760 \times \left(\frac{UA_{base}}{CE_{base}} - \frac{UA_{ee}}{CE_{ee}}\right) \times 10^{-6}$$

$$Combustion\ Efficiency\ Save, MMBtu = Gallons\ per\ year \times \Delta T_{cold,tank} \times \left(\frac{1}{CE_{base}} - \frac{1}{CE_{ee}}\right) \times Energy\ Conversion$$

$$Summer\ Loss = Gallons\ per\ summer \times \Delta T_{cold,tank} \times \left(\frac{1}{EF_{summer,ee}} - \frac{1}{EF_{ee}}\right) \times Energy\ Conversion$$

$$EF_{summer,ee} = Summer\ De-rating\ Factor \times EF_{ee}$$

$$EF_{ee} = Boiler\ AFUE - 0.0019 \times Storage\ Volume\ .^{23}$$

Aside from the difference in summer efficiency losses in the MA Method algorithm, adjusting for similar units[45] and using the same inputs results in identical savings between the NYTM equation and the MA Method.

Summer losses occur when the main (or only) demand on a boiler during the summer months is for the indirect water heater. Because no space heating is being demanded by the occupants, the system runs at significantly less than design load, producing just enough heat for the indirect water heater. A boiler at part load will typically operate less efficiently than a boiler operating at design load (as demonstrated by boiler efficiency curves). AFUE and other measures of efficiency are calculated as average efficiencies, assuming that a system is running when heating is needed to heat a home, but not assuming need for a system to run year-round at less than design load. In order to account for this decrease in efficiency, the summer losses term included in the MA Method algorithm includes a "de-rating factor," accounting for the decrease in system efficiency when not running at design load.

Inclusion of a term to reflect summer losses results in a relatively small decrease in savings but, in our judgment, would better represent savings from installing an indirect water heater.

Suggested Changes

Because we were not able to determine the source of the inputs to the NYTM formula for UA_{base}, and because the overall equation is very sensitive to this input, we suggest revising the UA_{base} equation listed in the NYTM to specify more clearly the source of its assumptions.[46] Alternatively, for larger-sized water heaters where

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[45] Changed the MA Method output from MMBtu to therms to be consistent with the NYTM.

[46] During the DPS review process, the TecMarket team clarified that the equation for UA_{base} in the NYTM is derived from the DOE standard test protocols used to rate the energy factor (EF) of storage water heaters (10 CFR Part 430 Energy Conservation Program for Consumer Products: Test Procedures for Water Heaters. Federal Register 63 (90) 25995-26016, 11 May 1998).

stand-by loss data is available, more standardized estimates of UA_{base} could be used, such as the formula suggested by ASHRAE:

UA_{base} = Standby loss / $\Delta T_{tank,\ ambient}$

We also suggest that inclusion of a term to cover summer losses in the NYTM algorithm for indirect water heaters be considered. Finally, we recommend updates to the NYTM to more clearly explain the variation in UA_{base} values for seemingly similar baseline water heaters in different NYTM sections or, if necessary, to make values more consistent.

4.1.7 Programmable Thermostats

NYTM Description

Setback Thermostat

Programmable setback thermostats applied to single family and multi-family residential air conditioners, heat pumps, boilers, furnaces and electric resistance baseboard heating systems.[47]

NYTM Algorithm

$$\Delta therms = units\ x\ \frac{kBtuh_{in}}{unit}\ \text{x}\ \frac{EFLH_{heat}}{100}\ \text{x}\ ESF_{heat}$$

Algorithm Inputs

units – number of heating units installed under program

$kBtuh_{in}/unit$ – input capacity of system served by programmable thermostat

$EFLH_{heat}$ – heating equivalent full-load hours

ESF_{heat} – energy savings factor

Comments

The NYTM algorithm for thermostat savings is similar to those used in other TRMs. The algorithms presented in the Mid-Atlantic and Illinois TRMs roughly define thermostat savings as an energy savings factor multiplied by annual household heating load, the same way that the NYTM does. The only significant difference between the algorithms we reviewed is in Illinois, where the TRM includes an effective in-service rate term to account for thermostats that may not be installed or programmed correctly. While the HEHE Programs require thermostats to be installed by a qualified contractor, customers may still not program it. If research points toward a large percentage of thermostats not being programmed accurately, adding a similar term to the NYTM algorithm could capture thermostat savings more accurately.

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[47] New York Department of Public Service, page 53.

Inputs to the algorithm are simple and well defined, and default values suggested for heating unit capacity when customer-specific data are not available are reasonable, with the exception of overstated FLH values, discussed in the boiler & furnace algorithm section.

The other major variable is the choice of Energy Savings Factor (ESF). The NYTM uses a value of 6.8% from a 2007 RLW Analytics study[48] also used in the Mid-Atlantic TRM, which also aligns closely with a value of 6.2% calculated from program-specific research in Illinois. The Massachusetts TRM specifies a deemed savings value of 7.7 MMBtu/reset control, which aligns closely with the NYTM algorithm if reasonable default values are chosen, implying a similar ESF. In the context of other TRMs, the NYTM assumptions appear reasonable and appropriate.

However, multiple recent evaluations[49,50] and our current evaluation have found lower-than-expected programmable thermostat savings, calling the 6.8% ESF used in the NYTM and Mid-Atlantic TRM into question. Another recent evaluation for New York State Electric and Gas (NYSEG) and Rochester Gas and Electric (RG&E) rolls programmable thermostat savings into those claimed for heating equipment due to conflicting information in the literature and difficulty in billing analysis due to small sample sizes.[51]

The ex-post gross savings analysis for programmable thermostats in this report found a realization rate of 22%. As discussed in the boiler reset control section, this realization rate is likely partially due to overstated NYTM FLH values, but unlike boiler reset controls, if FLH values were revised downward as a result of this evaluation, the NYTM algorithm would still likely significantly overstate savings for programmable thermostats.

Suggested Changes

In light of recent evaluation findings, we suggest further research into the appropriate choice of ESF for programmable thermostats in New York. If further research aligns with recent findings, a change in the ESF specified may be necessary.

4.2 Gross Impact Results

The analysis of gross impacts relied on three complementary approaches:

1. A household-level regression to find full-load hour (FLH) values for heating equipment; NYTM engineering algorithm with regression-based FLH used to estimate gross savings.

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[48] *Validating the Impact of Programmable Thermostats,* prepared for GasNetworks by RLW Analytics. 2007.

[49] *NYSERDA 2007-2008 EmPower New York[SM] Program Impact Evaluation Final Report,* prepared for the New York Energy and Research Development Authority by Megdal and Associates. April 2012. Page ES-8.

[50] *NYSERDA 2007-2008 Home Performance with Energy Star® Program Impact Evaluation Final Report,* prepared for the New York Energy and Research Development Authority by Megdal and Associates. September 2012. Page 4-7.

[51] *NYSEG/RG&E Residential Gas Process and Impact Evaluation*, prepared for New York State Electric and Gas and Rochester Gas and Electric by KEMA, Inc. April 2013. Page 5-12.

2. A pre/post billing analysis using a cross-section-time-series fixed-effects regression model to estimate retrofit savings for installation of boiler reset controls, thermostats, and sealing; and

3. Engineering analysis to characterize savings from indirect water heaters.

Table 4-2 summarizes PA-level ex ante program savings, our estimated realization rates, and the ex post savings (estimated by applying the realization rates to ex ante savings) for 2009 to 2011. The table shows that estimated realization rates range from 50% for National Fuel to 68% for Corning.[52]

Table 4-2. Summary of Gross Savings (2009-2011)

PA	Ex Ante Program Savings (Therms)	RR	Ex Post Program Savings (Therms)
Central Hudson	194,782	57%	111,406
Con Edison	863,985	52%	448,550
Corning	119,180	68%	81,531
Enbridge	91,348	61%	55,675
National Fuel	6,560,295	50%	3,264,486
KEDLI	955,067	61%	582,657
KEDNY	668,990	62%	416,473
NiMo	5,224,681	54%	2,797,021
O&R	325,988	63%	204,486
Statewide	15,004,317	53%	7,962,286

Table 4-3 presents additional detail on per unit realization rates, by PA and by measure. Measure-level gross realization rates are the final output of the gross impact evaluation. The following sections of this chapter describe the results of each component of the gross impact analysis that we used to calculate these realization rates.

[52] Note that we do not present estimates of the precision of our results as our gross impact analyses did not involve sampling.

Table 4-3. Per Unit Gross Realization Rate Summary (2009-2011)[a]

	Furnace with ECM	Furnace without ECM	Water Boiler	Steam Boiler	Indirect Water Heater	Boiler Reset Control	Thermostat	Sealing
Evaluation Method	Post-Installation Billing and FLH Analysis				Engineering Analysis	Pre/Post Billing Analysis		
Central Hudson	77%				23%	63%	22%	93%
Con Edison	81%				10%			
Corning	75%				n/a [b]			
Enbridge	60%				n/a [b]			
National Fuel	59%				105%			
KEDLI	66%				191%			
KEDNY	66%				189%			
NiMo	61%				192%			
O&R	70%				87%			
Statewide	62%	60%	65%	69%	52%	63%	22%	93%

[a] This table reflects per-unit gross realization rates that we developed through impact evaluation of records in the program-tracking database that had savings values. The final realization rates for a PA, measure, or program may be very slightly higher, to account for records in the program-tracking database that had missing savings values.

[b] Corning Gas and Enbridge St. Lawrence did not estimate savings from indirect water heaters in the program-tracking databases.

Table 4-4 below summarizes ex post savings after applying realization rates to ex ante savings in the 2009-2011 program-tracking databases. The overall program realization rate is 53%. The largest single contributor to the low realization rate is the programmable thermostat measure. Although savings per home are relatively small, it was the most commonly installed measure. Program-tracking savings indicated that expected savings were approximately 10% of average annual consumption, whereas the analysis done in this evaluation (and supported by other recent evaluations in New York) suggest that programmable thermostats can achieve savings in the range of 2% to 4% of annual consumption.

The heating equipment replacement measures (boilers and furnaces) account for most of the remaining drop in the realized savings. The primary underlying issue with these savings is that the FLH estimates in the NYTM appear to be overstated.

Table 4-4. Ex Post Gross Impact Summary

Measure	Number of Installed Units	Per-Unit Savings (therms)		Average per-Unit Gross Realization Rate [a]	Total Program Savings (therms)		Total Gross Realization Rate [d]
		Average Ex Ante Gross Savings	Average Ex Post Gross Savings		Total Ex Ante Gross Savings [b]	Total Ex Post Gross Savings [c]	
Furnaces w/ ECM	19,583	238	147	62%	4,650,401	2,868,914	62%
Furnaces	21,555	198	119	60%	4,256,953	2,556,643	60%
Water Boilers	9,468	177	116	65%	1,671,198	1,095,037	66%
Steam Boilers	4,174	134	93	69%	559,391	386,956	69%
Indirect Water Heaters	3,521	147	77	52%	508,812	270,515	53%
Boiler Reset Controls	1,070	75	47	63%	78,894	50,352	64%
Programmable Thermostats	38,687	85	19	22%	3,267,052	721,318	22%
Air Sealing	104	125	121	97%	11,616	12,552	108%
Totals	98,162	153	81	53%	15,004,317	7,962,286	53%

[a] This column reflects the per-unit realization rates calculated through gross impact analysis. For heating equipment replacement measures, realization rates were calculated at a PA level, and the realization rate in this table reflects weighting by ex ante savings. For all other measures, realization rates were calculated at an aggregate level (i.e., across all PAs).

[b] The sum of non-missing savings in the program-tracking data.

[c] This column accounts for records in the program-tracking database with missing savings values, by attributing average ex post savings for the PA and measure category to all units with missing values.

[d] This column accounts for records with missing savings values in the program-tracking database. To calculate total ex post savings, we attributed average ex post savings for the PA and measure category for all units with missing values. We then calculated a final realization rate as the ratio of total ex post savings divided by savings claimed in the program-tracking data (which had some missing values).

4.2.1 Post-Installation Billing Analysis and FLH Estimates

This section describes results of post-installation billing analysis used to develop estimates of full-load hours (FLH) for homes with high-efficiency heating equipment. FLH is one of the key inputs into the calculation of gross savings for the following measures:

- Furnaces
- Furnaces w/ECM
- Water Boilers
- Steam Boilers

The FLH analysis estimated savings as the difference in natural gas consumption between the installed heating equipment and heating equipment of the same type with minimum code-compliant efficiency, assuming both were run to provide the full heating needs of the household.

FLH Results

Table 4-5 below presents revised FLH estimates by climate zone. For some PAs, the information required to perform the FLH analysis was not available for all customers with heating equipment installations. Due to the variation in drops across PAs, particularly KEDLI and KEDNY, we aggregated results of FLH analysis at the climate zone level. The New York City climate zone includes Con Edison, KEDLI and KEDNY, the Poughkeepsie climate zone includes Central Hudson and O&R while all other climate zones are comprised of a single PA.

Table 4-5. FLH Estimates Based on Post-Installation Billing Analysis

NYTM Climate Zone	Program Administrators	Participants in Analysis		Normalized Annual Heating Degree-Days [a]	Estimated FLH
		Number	% of Participants with Heating Equipment Incentive		
Albany	NiMo	1,619	20%	6,580	978
Binghamton	Corning	239	61%	6,797	1,136
Buffalo	National Fuel	16,319	66%	6,502	1,032
Massena	Enbridge	266	91%	7,718	889
NYC	Con Edison, KEDLI, KEDNY	2,513	24%	4,961	786
Poughkeepsie	Central Hudson, O&R	1,060	73%	5,501	862
Syracuse	NiMo	1,558	20%	6,636	1,042

[a] Among participants in the FLH models.

We calculated ex post gross savings for all participants in the FLH analysis by using the revised FLH estimates, combined with existing assumptions in the program-tracking data about the capacity and efficiency of new equipment. We compared these ex post savings using new FLH estimates with ex ante savings, among all participants in the FLH analysis. Realization rates for each PA are presented in Table 4-6 below. We calculated realization rates at a PA level due to observed differences in how PAs calculated ex ante savings.[53]

[53] The NYTM provides an algorithm for calculating savings from heating system replacement, and allows for a choice between multiple FLH assumptions based on home vintage and home type. We determined through an examination of program-tracking data that PAs may have chosen different values from among the values applicable to their climate zone. Further, while actual heating system capacity for each specific unit is a preferred input for calculating savings, some PAs used an average value (the same for all customers) in the absence of capacity information for each specific unit. Therefore, we expect realization rates to vary by PA.

Table 4-6. Heating Equipment Realization Rates by PA[a]

Program Administrator	Participants in Analysis		Average per-Unit Savings (therms)		Heating System Realization Rate [a]
	Number	% of Participants with Heating Equipment Incentive	Ex Ante	Ex Post	
Central Hudson	245	43%	206	159	77%
Con Edison	1,920	82%	193	156	81%
Corning	239	61%	240	181	75%
Enbridge	266	91%	281	167	60%
National Fuel	16,319	66%	191	112	59%
National Grid (KEDNY + KEDLI)	593	7%	170	112	66%
NiMo	3,177	20%	243	148	61%
O&R	815	91%	219	154	70%
TOTAL	23,574	44%	200	124	62%

[a] These realization rates are applied to all heating equipment replacement measures: furnaces, furnaces with ECM, water boilers, and steam boilers.

Validation

We took two approaches to validating our results. First, we compared FLH values to a recent (2013) HEHE program evaluation in New York State, conducted by DNV KEMA for NYSEG/RG&E.[54] Second, we conducted a pre/post billing analysis to understand retrofit savings for these measures. A comparison of the results of this evaluation with the NYSEG/RG&E Evaluation is presented below, the pre/post billing analysis results are described in the next section.

Comparison to NYSEG/RG&E Analysis

The FLH values estimated in this evaluation are slightly higher than the values estimated from a recent (2013) NYSEG/RG&E gas HEHE program evaluation. In Table 4-7 below, we compare:

- NYSEG/RG&E FLH values that are broken out by measure category and use TMY data. Although the NYSEG/RG&E evaluation does not distinguish results by climate zone, we selected three weather zones that are the closest to NYSEG and RG&E territory for comparison.
- Ex post FLH values estimated through this evaluation, which are broken-out by climate zone and use more recent 10-year weather data.

[54] Source: KEMA, Inc. NYSEG/RG&E Residential Gas Process and Impact Evaluation. April 2013. See page 1-20. Report available at: http://www.nyseg.com/MediaLibrary/2/5/Content%20Management/Shared/UsageAndSafety/PDFs%20and%20Docs/2013_NYSEG_RGE_Residential_Gas_HVAC_Program_Evaluation_Report.pdf

Table 4-7. Comparison of Statewide HEHE Program Evaluation FLH Estimates with NYSEG/RG&E HEHE Evaluation (2013)

Evaluation	Measure or Climate Zone	FLH w/ 10-Year Averages	FLH w/ TMY Data[a]
NYSEG / RG&E Evaluation (2013)[b]	Boilers	n/a	800
	Furnaces without ECM	n/a	858
	Furnaces with ECM	n/a	911
Statewide Evaluation	Binghamton	1,136	1,075
	Syracuse	1,042	1,049
	Buffalo	1,032	1,048

[a] The NYSEG/RG&E report does not specify whether TMY data is TMY2 or TMY3; we are assuming they used TMY3.

[b] Source: KEMA, Inc. NYSEG/RG&E Residential Gas Process and Impact Evaluation. April 2013. See page 1-20. Report available at: http://www.nyseg.com/MediaLibrary/2/5/Content%20Management/Shared/UsageAndSafety/PDFs%20and%20Docs/2013_NYSEG_RGE_Residential_Gas_HVAC_Program_Evaluation_Report.pdf Ibid.

The realization rates and ex post savings observed in this evaluation are in line with the results of the NYSEG/RG&E Evaluation, as shown in Table 4-8 below.

Table 4-8. Comparison of Ex Post Savings and Realization Rates between Statewide HEHE and NYSEG/RG&E Evaluation

	Statewide HEHE			NYSEG/RG&E Evaluation (2013)[c]		
Measure	Average Ex Ante[a]	Average Ex Post	Average per-Unit Gross Realization Rate[b]	Full TRM Savings	Average Ex Post	Realization Rate
Furnaces with ECM	238	147	62%	284	131	46%
Furnaces without ECM	198	119	60%	246	128	52%
Water Boilers	177	116	65%	356	156	44%
Steam Boilers	134	93	69%			

[a] Ex ante values among all 2009-2011 program participants with non-missing savings values in the program-tracking data.

[b] Weighted average realization rate across all PAs, weighted by ex ante savings per PA with each measure installation.

[c] Ibid., see Table 1-6.

Discussion

We compared our ex post FLH estimates with the FLH assumptions in the NYTM. Table 4-6 below compares our FLH estimates with FLH assumptions for an “average vintage” single-family home from the NYTM, showing that the FLH values from the billing analysis range from 16% to 41% lower. The climate zone with the greatest variation is Massena. The reasons for such a large difference are not clear. Although this climate zone also has a relatively small number of homes used as the basis for the FLH calculations (266), this number represents the majority of Enbridge St. Lawrence HEHE program participants with heating system installations (91%).

Table 4-9. FLH Estimates Compared with NYTM Assumptions[55]

NYTM Climate Zone	Normalized Annual Heating Degree-Days[a]	N	Ex Post FLH	NYTM Assumption for Average Single-Family Home[b]	
				FLH	Ex Post FLH % Difference
NYC	4,961	2,513	786	934	-16%
Poughkeepsie	5,501	1,060	862	1,157	-26%
Buffalo	6,502	16,319	1,032	1,473	-30%
Albany	6,580	1,619	978	1,379	-29%
Syracuse	6,636	1,558	1,042	1,391	-25%
Binghamton	6,797	239	1,136	1,450	-22%
Massena	7,718	266	889	1,496	-41%
Statewide Average[c]	6,324	23,574	995	1,389	-28%
Downstate Average	4,961	2,513	786	934	-16%
Upstate Average	6,486	21,061	1,020	1,444	-29%

[a] Normalized HDD are weighted to reflect the location of participants in the FLH analysis.

[b] The NYTM allows administrators to select among multiple FLH values for each climate zone. These values are differentiated by single-family/multifamily and home vintage (old, average, or new)

[c] Averages are weighted by the number of participants in FLH analysis

Some possible reasons for the differences between the FLH billing analysis results and the NYTM FLH values are described below.

- The NYTM values are based on modeling using a DOE-2.2 simulation of prototypical residential buildings. The "average" prototype assumes average insulated buildings conforming to 1980s-era building codes. It is possible that HEHE program homes may be newer or better insulated, on average, meaning that less heating is required.
- The NYTM FLH estimate was most likely based on the assumption that the homes had natural gas as the only heating source, and that natural gas use was highly correlated with heating degree-days. Actual homes do not necessarily conform to these assumptions. When the model was restricted only to homes with a very strong linear relationship between natural gas use and heating degree-days, the FLH estimates from the model were higher than the preliminary FLH estimates shown in Table 4-9.[56]
- Our modeling showed that some homes exhibited heating consumption patterns that were consistent with having a secondary heating source. A second fuel would reduce the FLH for the primary heating system. The heating patterns in about 5% of homes suggested that there was a substantial

[55] New York Standard Approach for Estimating Energy Savings from Energy Efficiency Programs: Residential, Multi-Family, and Commercial/Industrial Measures. October 15, 2010. Prepared for the New York Department of Public Service. Page 431.

[56] The analysis of homes with a "very strong" linear relationship between natural gas use and heating degree-days included only homes with an R^2 value of 0.975 or greater from the house-by-house regression (n=8,504).

contribution from another heating fuel.[57] The proportion of homes that appeared to have a substantial contribution from another heating fuel was fairly consistent across climate zones (ranging from 2-7%).

- The NYTM uses "Typical Meteorological Year" (TMY3) data in modeling. The Opinion Dynamics team used the 10-year normalized heating degree-days in this analysis to reflect the recent warming trend, which is consistent with the approved evaluation work plan. While not an industry standard yet, many evaluators are choosing to use 10-year averages instead of these longer averages, because of warming trends seen and expected to continue as the "new normal." Table 4-10 below shows a comparison of FLH results estimated with 10-year weather normals compared with TMY3 data. The 10-year normalized heating degree-days are about 1.4% lower overall than the TMY3 data, which are based on a slightly longer but earlier timeframe. This analysis suggests that differences in FLH between this evaluation and the NYTM are likely driven by differences in how equipment is used and physical characteristics of the home (e.g., envelope characteristics, system sizing) rather than weather differences.

Table 4-10. Comparison of Evaluated FLH with 10-Year Weather Normals and TMY3 Weather Normals

NYTM Climate Zone	FLH Estimates Using TMY3 Data	FLH Estimates Using 10-Year Weather	Percentage Difference (10-year vs. TMY3)
NYC	815	786	-4%
Poughkeepsie	897	862	-4%
Buffalo	1,048	1,032	-2%
Albany	999	978	-2%
Syracuse	1,049	1,042	-1%
Binghamton	1,075	1,136	6%
Massena	884	889	1%
Statewide Average [a]	1,012	995	-2%
Downstate Average [a]	815	786	-4%
Upstate Average [a]	999	1,020	2%

[a] Averages are weighted by the number of participants in FLH analysis

Based on the FLH analysis, we believe that current FLH assumptions are resulting in overstated ex ante savings. These findings align with results from the NYSEG/RG&E HEHE Evaluation. We recommend additional dialogue with New York stakeholders (i.e., the PAs, the Technical Manual Review Committee, the DPS, and the TecMarket team) about potential updates to the NYTM. If stakeholders wish to modify FLH assumptions for planning purposes, we would recommend applying an adjustment factor to FLH assumptions in the NYTM (see page 431 of the October 15, 2010 NYTM) based on the average difference between FLH assumptions in the NYTM and evaluated Ex Post FLH. For the five climate zones with more than 1,000 participants represented in our FLH analysis, we would recommend using climate zone-specific adjustments for each climate zone (see the last column of Table 4-10). For climate zones with less than 300 participants represented in our FLH analysis (Binghamton and Massena), we would recommend using an Upstate weighted average adjustment.

[57] Homes with an R^2 value from the house-by-house regression between 0.30 and 0.70 were assumed to have another source of heat in addition to natural gas.

Table 4-11. Differences Between NYTM FLH Assumptions and Ex Post FLH

NYTM Climate Zone	N	Ex Post FLH	NYTM Assumption for "Average Vintage" Single-Family Home		Recommended Adjustment
			FLH	Ex Post FLH % Difference	
NYC	2,513	786	934	-16%	-16%
Poughkeepsie	1,060	862	1,157	-26%	-26%
Buffalo	16,319	1,032	1,473	-30%	-30%
Albany	1,619	978	1,379	-29%	-29%
Syracuse	1,558	1,042	1,391	-25%	-25%
Binghamton	239	1,136	1,450	-22%	-29% [a]
Massena	266	889	1,496	-41%	-29% [a]
Statewide Average [b]	23,574	995	1,389	-28%	n/a
Downstate Average	2,513	786	934	-16%	n/a
Upstate Average	21,061	1,020	1,444	-29%	n/a

[a] Based on the Upstate average
[b] Weighted by the number of participants in FLH analysis

4.2.2 Pre/Post Billing Analysis

We conducted pre/post installation billing analysis among all participants with valid billing and participation data. The results from this model provide an estimate of the retrofit savings for the included measures (i.e., the baseline is the pre-installation condition in each home). For some measures, such as programmable thermostats, retrofit savings are the best-available method to estimate the program savings. For other measures, these retrofit savings provide a reality check for the replacement-on-failure savings estimated through the FLH analysis. The specific approach for each measure is discussed below.

- For thermostats, boiler reset controls, and air sealing, the pre/post billing analysis is the primary method of calculating ex post program savings. While we expected to use engineering analysis to calculate air sealing savings, the results from billing analysis were stable enough to use billing analysis results.
- For heating systems, the pre-post analysis is only a sanity check on the results of the evaluated savings using the updated FLH values, which we expect to be a more accurate reflection of savings relative to the federal standard. The pre/post billing models estimate the measure savings in comparison to the equipment that was in use prior to the installation. Therefore, the savings observed through models is not equivalent to the program savings calculation, which is meant to capture consumption changes relative to a federal standard rather than existing equipment.
- For indirect water heaters, which affect natural gas baseload, the pre/post billing analysis was not found to be an effective method of estimating savings, and an engineering analysis was used

instead.[58] However, indirect water heater installations are still reflected in the model, because they may affect natural gas consumption for households with multiple measure installations.

The final model includes participants with all measure installations. We included all measures in the final model to ensure that the savings for heating system replacements did not inadvertently inflate the savings for the other measures. We also added a variable to capture the extra use from homes that appeared to have undertaken a fuel conversion, to ensure that pre/post results for each measure category reflect changes among homes that previous used natural gas for heating.

The sections below describe findings and implications of the pre/post billing analysis.

Results for Controls and Air Sealing

For programmable thermostats, boiler reset controls, and air sealing, the pre/post billing analysis model is the primary method of assessing gross impacts and realization rates. The model results are compared to the program-reported savings in Table 4-12 below.

Table 4-12. Pre/Post Billing Model Results for Control and Air Sealing Measures

Measure	Number of Homes in Model	Pre/Post Modeled Savings per Home	Program-Reported Savings per Home	Realization Rate (Modeled Savings % of Program Savings)
Thermostat	25,083	20	92	22.1%
Boiler Reset Control	489	46	73	62.8%
Air Sealing	41	181	194	93.3%

The findings for these measures are discussed below.

- Programmable Thermostats: The pre/post savings indicate that the program-rebated thermostats save about 20 therms per year per home, or about 2% of average annual pre-installation consumption. These savings are substantially lower than the average program-reported savings of 92 therms per year, which represents about 10% of annual consumption of the homes in the model.
- Boiler Reset Controls: The pre/post billing analysis indicates that this measure saves about 46 therms per year on average, or about 5% of annual pre-installation consumption. Although these savings are aligned with the NYTM on a percentage basis (the NYTM estimates an ESF of 5%), the realization rate is 63% due to lower-than-expected annual heating load of HEHE program participants.
- Air Sealing: Pre/post savings are in line with program-tracking estimates. Note that very few participants installed air sealing measures.

[58] Savings from indirect water heaters comprised only 3.4% of ex ante gross savings.

Results for Heating Systems

For furnace and boiler installations, we would expect the older equipment to be less efficient than the current federal standards for new equipment, which are used in the calculations for both the program-reported savings and the evaluated savings using the updated FLH. Thus, the pre/post analysis would be expected to result in higher savings than the FLH approach. A brief summary of the pre/post model findings for heating systems is provided below; the comparison of the results from the two approaches is presented in Table 4-13.

- High-Efficiency Furnaces: The pre/post analysis shows savings that are quite close to the estimated savings using the FLH approach.
- High-Efficiency Furnaces with ECM: The estimated pre/post savings for ECM furnaces are lower than the FLH analysis; this result may indicate that the existing furnaces prior to replacement were of a higher efficiency than the current federal standards.
- Water Boilers: The pre/post model shows savings for water boilers that are substantially higher than the FLH approach. This result may indicate that the efficiency of the existing equipment prior to the installation was much lower than the current federal standards. As older boilers tend to have a longer measure life than many of the newer ones, it is possible that some very old and low-efficiency equipment was removed.
- Steam Boilers: These homes show a substantial increase in consumption during the post-installation period. We investigated this counterintuitive finding, and the results indicated that there was an unusually high percentage of homes that did not appear to be using natural gas as the primary space heating fuel during the pre-installation period. When the model was restricted to homes that showed primary natural gas space heating during the pre-installation period, the model showed modest savings. These results are included in Table 4-13 in the row titled “Steam Boilers – Primary Space Heat Only.” There are also relatively few steam boiler installations, and they are largely clustered around the NYC area, in KEDNY territory.

Table 4-13. Comparison of Savings from Post-Installation Billing Analysis Method (FLH Approach) and Pre/Post Billing Analysis Validation

Measure	Number of Homes in Model	Pre/Post Modeled Savings per Home	FLH Modeled Savings per Home [a]	Program-Reported Savings per Home
Furnace	15,529	129	117	199
ECM Furnace	14,376	100	143	240
Water Boiler	3,934	160	107	203
Steam Boiler	974	(107)	113	138
Steam Boiler - Primary Space Heat Only	*781*	*53*	*113*	*139*

[a] These values are the ex post averages per measure category among all participants in the FLH model, because some of the participants in the pre/post model were not in the FLH model due to the data cleaning requirements.

Discussion

The pre/post billing analysis is the primary method of estimating savings for controls and air sealing. As such, we focus our discussion on the implications for these measure categories.

Programmable thermostats are commonly installed and represent 22% of the program-reported savings. The modeling shows that the evaluated savings are substantially lower than what has been assumed by the program. However, the magnitude of the average per-household savings from the model is in line with two recent evaluations of residential programs in New York. These studies found savings from programmable thermostats to be in the range of 22 to 38 therms per year per household, or about 2% to 4% of pre-installation natural gas consumption.[59]

Other research suggests that homeowners either do not understand how to use the programmable thermostats (suggesting that the available savings may not be achieved) or that they were already setting back their thermostats (manually) prior to installing the programmable thermostat (suggesting that the opportunity for savings may be much smaller). Given the large number of homes in the model and the similar results from other recent studies in New York, there are strong indications that the savings for programmable thermostats in the NYTM are overstated for participants in the HEHE program, and should be reassessed.

By contrast, boiler reset controls and air sealing are infrequently installed in this HEHE program and, in combination, account for less than 1% of program savings. The pre/post modeling suggests that the savings for boiler reset controls are about 63% of the program-reported value, and the realized air sealing savings are almost equal to the program reported values. We do not recommend pursuing changes to the NYTM for boiler reset controls at this time because ex ante boiler reset control savings will be impacted by any revisions to FLH values in the NYTM. If FLH values are revised downward based on this evaluation, boiler reset control ex ante savings would also decrease. We do not recommend pursuing changes to the air sealing algorithm in the NYTM because of the relatively low number of installations in this evaluation.

For heating system replacements, the comparison of the pre/post model results with savings based on revised FLH estimates presents a less clear picture. Furnaces and water boilers showed the expected result, with the pre/post savings higher than the FLH savings, suggesting that the pre-installation equipment was likely to be of a lower efficiency than the federal standard. In contrast, the ECM furnaces showed lower savings in the pre/post model. As the average efficiency of the ECM furnaces (0.93) was higher than the non-ECM furnaces (0.90), one would expect the savings from the pre/post model to be higher. The most likely explanation seems to be that the existing furnaces in the homes with new ECM furnaces were higher-efficiency than in the homes with non-ECM furnaces. An analysis of existing equipment characteristics might help to explain this result; however, such an analysis was not within the scope of this evaluation. Finally, water boilers showed no savings (due to the relatively high number of homes with very low pre-installation consumption).

[59] *NYSERDA 2007-2008 EmPower New York[SM] Program Impact Evaluation Final Report,* prepared for the New York Energy and Research Development Authority by Megdal and Associates. April 2012. Page ES-8.

NYSERDA 2007-2008 Home Performance with Energy Star® Program Impact Evaluation Final Report, prepared for the New York Energy and Research Development Authority by Megdal and Associates. September 2012. Page 4-7.

4.2.3 Engineering Analysis for Indirect Water Heaters

We used an engineering-based approach to calculate ex post savings for indirect water heaters (IWH). As documented in the DPS-approved work plan, we planned to estimate impacts for IWH installations using billing analysis, but default to engineering analysis if the billing analysis results were not stable or reliable. After reviewing the results from billing analysis, we decided to pursue the engineering-based approach because the models were unstable for this measure.[60] We conducted the analysis in two steps:

1. We first estimated ex post savings based on the algorithms in the NYTM.
2. We then developed an alternative analysis of savings by applying two recommended adjustments to the NYTM algorithms (based on our engineering review of measure-level savings algorithms) to IWH savings.

Below we describe the results of these two analyses.

Development of Ex Post Savings

Based on program-tracking data provided by the PAs, ex ante savings for IWH installations rebated through the HEHE program between 2009 and 2011 ranged from 40 therms per unit for the National Grid utilities (KEDLI, KEDNY, NiMo) to more than 750 therms per unit for Con Edison. Our ex post analysis of IWH savings yields per-unit savings between 68 therms for National Fuel and 86 therms for Enbridge.

Table 4-14 below summarizes, by PA, the total number of units rebated in the evaluation period (2009-2011), per-unit ex ante and ex post savings, and the realization rate (estimated by dividing ex post savings by ex ante savings). A comparison of ex ante and ex post per-unit savings shows that ex post savings are substantially higher than PA-estimated ex ante savings for the three National Grid utilities, and somewhat higher for National Fuel. Ex post savings are significantly lower for Con Edison and Central Hudson, and somewhat lower for O&R. Con Edison's very high ex ante values result from an error in the initial NYTM algorithm for IWH that produced inflated savings for installations between 2010 and 2012. The reason for the very high ex ante values for Central Hudson is unknown, but it might be associated with the same error present in the original version of the NYTM that affected the Con Edison numbers.

[60] This is not uncommon for "base use" measures such as indirect water heaters.

Table 4-14. Comparison of Ex Ante and Ex Post per-Unit Savings for Indirect Water Heaters

PA	Units Installed (2009-2011)	Average per-Unit Gross Savings (therms)		Realization Rate
		Ex Ante	Ex Post	
Central Hudson	154	362	84	23%
Con Edison	409	762	79	10%
Corning[a]	33	n/a	84	n/a
Enbridge[b]	31	n/a	86	n/a
National Fuel	366	65	68	105%
KEDLI	1,313	40	76	191%
KEDNY	369	40	75	189%
NiMo	543	40	77	192%
O&R	303	94	82	87%
Total	3,521	147	77	53%

[a] Corning's database did not contain savings values for IWH installations.

[b] Enbridge St. Lawrence did not provide specific savings values for IWH installations, but instead bundled savings with the associated boilers.

To determine total ex post savings for each PA, we applied the ex post unit savings to the total number of IWH installations during the evaluation period. Table 4-15 below compares the ex post program savings with the ex ante values provided by the PAs.

Table 4-15. Summary of Ex Ante and Ex Post Indirect Water Heater Savings

PA	Units Installed (2009-2011)	Ex Ante Gross Savings (therms)		Ex Post Gross Savings (therms)	
		Average per-Unit Savings	Total Savings	Average per-Unit Savings	Total Savings
Central Hudson	154	362	55,752	84	12,943
Con Edison	409	762	311,788	79	32,217
Corning[a]	33	n/a	-	84	2,768
Enbridge[b]	31	n/a	-	86	2,670
National Fuel	366	65	23,790	68	25,045
KEDLI	1,313	40	52,520	76	100,422
KEDNY	369	40	14,760	75	27,834
NiMo	543	40	21,720	77	41,761
O&R	303	94	28,482	82	24,855
Total	3,521	147	508,812	77	270,515

[a] Corning's database did not contain savings values for IWH installations.

[b] Enbridge St. Lawrence did not provide specific savings values for IWH installations, but instead, bundled savings with the associated boilers.

Alternative Analysis: Impact of Recommended NYTM Adjustments

In this alternative analysis, we applied the two recommended adjustments to the NYTM algorithm to the ex post savings values developed above. The two adjustments are:

1. Replacing the overall heat loss coefficient of the base water heater (UA_{base}) assumption in the NYTM with an ASHRAE formula[61] – this adjustment is recommended because the NYTM assumption for UA_{base} is not well documented and is substantially higher than assumption in other sources (including other parts of the NYTM). Ex post savings results are very sensitive to the UA_{base} value.
2. Accounting for summer losses – this adjustment is recommended because during summer months, there is less hot water demand in the home (no hot water is needed for space heating), resulting in decreased load on the boiler. A boiler at part load will typically operate less efficiently than a boiler operating at design load (as demonstrated by boiler efficiency curves). As a result, IWH savings would be overstated in the NYTM algorithm, which assumes a boiler operating at design-load efficiency during summer months.[62]

The overall effect of applying these two adjustments would be a reduction in ex post savings by approximately 50%. The majority of this reduction (approximately 77%) comes from the replacement of the NYTM assumption for UA_{base}; approximately 23% comes from subtracting summer losses.

4.2.4 EC Motor Ancillary Electric Savings

As part of the engineering review, we assessed the assumptions behind the EC Motor deemed savings value in the NYTM (733 kWh per furnace for EC Motors). This review suggested that additional research into EC motor operation and savings in the state of New York would be necessary to adjust the current value to be more specific to New York HEHE participants. Therefore, for the purpose of estimating ex post kWh savings, we are assigning the current NYTM savings value of 733 kWh per furnace to the counts of furnaces with EC motors for each PA. The table below shows ex post results for each PA.

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[61] ASHRAE uses: *UAbase = Standby loss / Change in ambient temperature*. Where: *Standby loss* is based on manufacturer data (in Btu/hr); *Change in ambient temperature* is the temperature difference between the stored hot water and the surrounding air (in degrees F).

[62] Summer losses would only apply if an IWH replaces a standard hot water heater, rather than another IWH. Our analysis of IWH savings is based on the assumption that the replaced unit is a standard hot water heater (the existing unit is not tracked by PAs and therefore not available); as a result, summer losses would be applicable to all IWHs included in our analysis.

Table 4-16. Ancillary Electric Savings for Furnaces with EC Motors

Program Administrator	ECM Furnace n	Total Estimated Ancillary Electric Savings (kWh)
Central Hudson[a]	222	162,726
Con Edison[b]	557	408,281
Corning	249	182,517
Enbridge	69	50,577
National Fuel	7,008	5,136,864
KEDLI	544	398,752
KEDNY	639	468,387
NiMo	10,047	7,364,451
O&R	248	181,784
Total	19,583	14,354,339

Database extracts for Central Hudson and Con Edison included ex ante savings for ECM furnaces:

- Central Hudson used the NYTM value of 733 kWh, but this value was only applied to 128 out of 222 rebated ECM furnaces. Applying the NYTM value to all 222 units results in a realization rate of 173%.
- Con Edison’s database showed an average of 620 kWh per unit for its 557 rebated ECM furnaces. Applying the NYTM value of 733 kWh to all 557 units results in a realization rate of 118%.

4.3 Net Impact Results

The net impact evaluation includes estimation of free-ridership and participant spillover. Free-ridership is the portion of verified gross savings that would have been realized absent the program and its interventions. Participant spillover occurs when participants take additional energy-saving actions that are influenced by the program interventions but did not receive program support.[63]

We used the following formula to calculate the net-to-gross ratio (NTGR):

$$NTGR = 1 - FR + Participant\ Spillover$$

We developed a program-level estimate of FR and participant spillover for each PA. In addition, we also estimated FR by PA group and measure.

The following subsections provide the results of the net impact analysis at the program level for each PA and statewide. Additional measure level results, by PA, PA Group, and statewide, are presented in Appendix A.

4.3.1 Summary of Net Impact Results

The estimated statewide NTGR for the evaluation period (2009-2011) is 61.8%. We estimate free-ridership to be 38.5% and spillover 0.3%. The NTGR ranges from 71.0% for KEDLI to 48.2% for Orange & Rockland (O&R).

[63] This evaluation does not include estimation of non-participant spillover.

This variation is due to differences in levels of free-ridership, which ranges from just under 30% for KEDLI to approximately 50% for O&R, Corning, and Enbridge. Participant spillover is uniformly low across PAs, ranging from no spillover for Enbridge and O&R to 1.5% for Corning.

Table 4-17 summarizes the program-level FR, participant SO, and NTGRs.

Table 4-17. Program Level NTGRs (2009-2011)

PA	Program Free-Ridership	Program Spillover	Program NTGR
Central Hudson	31.8%	0.5%	68.8%
Con Edison	36.5%	0.5%	64.1%
Corning	50.4%	1.5%	51.1%
Enbridge	47.8%	0.0%	52.2%
National Fuel	36.9%	0.3%	63.4%
KEDLI	29.6%	0.6%	71.0%
KEDNY	37.5%	0.4%	62.9%
NiMo	41.5%	0.3%	58.8%
O&R	51.8%	0.0%	48.2%
Upstate	39.1%	0.3%	61.2%
Downstate	36.2%	0.4%	64.2%
Statewide	38.5%	0.3%	61.8%

We calculated net program impacts for 2009-2011 by multiplying the program-level ex-post gross impact results by the program-level NTGR. Program net impacts, by PA and statewide, are shown in Table 4-18 below.

Table 4-18. Program Level Net Impacts (2009-2011)

PA	Ex-Post Gross Impacts (Therms)	Program Level NTGR	Ex-Post Net Impacts (Therms)
Central Hudson	111,406	68.8%	76,596
Con Edison	448,550	64.1%	287,313
Corning	81,531	51.1%	41,673
Enbridge	55,675	52.2%	29,057
National Fuel	3,264,486	63.4%	2,070,017
KEDLI	582,657	71.0%	413,603
KEDNY	416,473	62.9%	261,855
NiMo	2,797,021	58.8%	1,644,122
O&R	204,486	48.2%	98,639
Upstate	6,310,120	61.2%	3,861,466
Downstate	1,652,167	64.2%	1,061,410
Statewide	7,962,286	61.8%	4,922,876

4.3.2 Free-Ridership Results

Participant survey results served as our primary data source for our free ridership estimates. We supplemented these survey results with information from participating contractors, to account for program influences on contractors that are not visible to participants. Contractors, identified by at least one participating customer as having influenced their decision to install high-efficiency equipment, were asked a series of questions about the influence of the HEHE program on: 1) their knowledge of high-efficiency gas heating equipment and comfort level when recommending high-efficiency equipment, and 2) any increase in their recommendations of high-efficiency equipment. We used this information to adjust the participant free-ridership results.[64]

Table 4-19 provides an overview of the results at the statewide level and by PA. The table presents the following information:

- Column A, "Unadjusted Participant FR," shows free-ridership rates solely based on participant responses.
- Column B, "Minimum FR," shows the minimum level of FR, if all interviewed contractors reported that the HEHE program was 100% responsible for any increases in their recommendations of high-efficiency equipment since the program began. This would be the level of FR if the FR score for all participants who had identified their contractor as influential (a score of 6 or 7 on a seven-point scale) was zero.
- Column C, "Maximum Adjustment," is the difference between Column A and Column B, i.e., the maximum possible reduction in participant-reported FR as a result of the contractor adjustment.
- Column D, "Program Influence on Contractors," shows the percentage of the increase in their recommendations of high-efficiency equipment (if any) that contractors attribute to the HEHE program. This percentage was developed directly from contractor survey responses and estimated at the PA group level.[65]
- Column E, "Contractor Adjustment," shows the adjustment to the participant FR score, based on the program's influence on contractors. This adjustment is the product of Column C and Column D, i.e., the share of the maximum adjustment that is attributable to the HEHE program. This adjustment was applied to only those participants who reported that their contractor influenced their decision to install high-efficiency heating equipment.
- Column F, "Adjusted FR," presents the final FR score for each PA, calculated as the difference between Column A and Column E.

The unadjusted participant FR rate is 52% statewide and ranges from 36% for KEDLI to 66% for Corning. However, participants report that contractor had a strong influence on the installation of 58% of measures

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[64] The contractor survey also included a second set of questions intended to produce an independent estimation of free-ridership. Due to the low number of valid responses and inconsistencies in open-ended, clarifying questions, we do not include results of this analysis in this report.

[65] The three PA groups are defined as follows: Group 1: National Fuel; Group 2: KEDLI, KEDNY, and Con Edison; Group 3: NiMo, Central Hudson, Corning, Enbridge, and O&R.

rebated through the HEHE Programs, leading to a relatively high maximum possible FR adjustment of 29% statewide, ranging from 16% for O&R to 40% for Corning. Notably, the two PAs with the highest unadjusted participant FR, Corning and Enbridge, also have the highest possible maximum adjustment.

Overall, contractors report a significant influence of the HEHE Program on their recommendations of high-efficiency equipment, ranging from 40% for Group 3 to 55% for Group 1, with a statewide average of 45%. This influence results in a contractor FR adjustment of 13% statewide, with a range of 6% for O&R and 18% for National Fuel.

Based on the participant and contractor surveys, we estimate the final adjusted statewide free-ridership to be 39%. By PA, the adjusted FR ranges from 32% for Central Hudson to 52% for O&R. All adjusted free-ridership scores meet DPS requirements for 10% precision or better at 90% confidence. We attempted a census of participants for three PAs (Corning, Enbridge, and O&R) due to the small size of the participant population; for these PAs, there is no sampling error. For the remaining six PAs, precision levels range from 4% for KEDLI to 8% for Con Edison. Since we attempted a census of contractors who were identified as influential by participating customers, there is no sampling error associated with the contractor adjustment estimate.

Table 4-19. Summary of Free-Ridership Estimates, by PA

PA	(A) Unadjusted Participant FR	(B) Minimum FR	(C) Maximum Adjustment (A-B)	(D) Program Influence on Contractors[a]	(E) Contractor Adjustment (C*D)	(F) Adjusted FR (A-E)
Central Hudson	42.5%	15.3%	27.2%	39.6%	10.7%	31.8%
Con Edison	46.8%	16.3%	30.5%	33.7%	10.3%	36.5%
Corning	66.3%	26.1%	40.2%	39.6%	15.9%	50.4%
Enbridge	61.1%	27.5%	33.6%	39.6%	13.3%	47.8%
National Fuel	54.6%	22.3%	32.3%	54.9%	17.8%	36.9%
KEDLI	35.6%	17.7%	17.9%	33.7%	6.0%	29.6%
KEDNY	46.4%	20.1%	26.4%	33.7%	8.9%	37.5%
NiMo	52.3%	25.1%	27.2%	39.6%	10.8%	41.5%
O&R	57.9%	42.3%	15.6%	39.6%	6.2%	51.8%
Statewide	51.6%	23.0%	28.7%	44.8%	13.1%	38.5%

[a] Program influence on contractors was developed at the PA group level: Group 1 = 54.9%, Group 2 = 33.7%, Group 3 = 39.6%.

4.3.3 Spillover Results

We estimated participant spillover based on responses to the participant survey. Overall, 35% of participants report having made additional energy-efficient upgrades to their home for which they did not receive a rebate from their PA. These participants report making an average of 2.4 additional improvements per home. However, a much smaller share of these upgrades (7%) were significantly motivated by the HEHE Programs.[66] We asked these respondents to describe, in their own words, the program's influence on their actions. A review

[66] A response 6 or 7 on a scale of 1 to 7, where 1 is "no influence" and 7 is "a great deal of influence" when participants were asked to rate the influence of their experience with the Programs on their decision to install the additional energy efficient measure.

of these open-ended responses confirmed that 18 of the improvements qualified as participant SO. Of these, 15 would generate natural gas savings and were included in the SO analysis.

We estimated savings for the 15 installations, using either NYTM algorithms or ex post savings estimates (as developed in this evaluation), where possible. Table 4-20 presents the estimated spillover savings for survey respondents, by PA and by measure.

Appendix A provides additional detail on how spillover savings were calculated for individual measures.

Table 4-20. Total Spillover Savings Per Measure Among Surveyed Program Participants

PA	# of Participants with Measure	Measure	SO Savings (Therms)
Central Hudson	1	Storage Water Heaters	32
	1	Tankless Water Heaters	42
Con Edison	1	Programmable Thermostats	100
Corning	1	Attic Insulation	97
National Fuel	1	Attic & Basement Insulation	16
	1	Indirect Water Heaters	68
	1	Storage Water Heaters	32
	2	Windows	8
KEDLI	1	Indirect Water Heaters	76
	1	Low Flow Showerheads	17
	1	Windows	16
KEDNY	1	Storage Water Heaters	78
NiMo	1	Indirect Water Heaters	77
	1	Tankless Water Heaters	66

For each PA, we estimated the SO rate by dividing the PA's estimated SO savings by the total ex post program savings realized by the PA's survey respondents. Spillover is generally minimal, ranging from 0% for Enbridge and O&R to 1.5% for Corning (see Table 4-21). We estimated the statewide SO rate to be 0.3%, estimated as the ex post savings weighted average of each PA's SO rate.

Table 4-21. Spillover Rates by PA

PA	Spillover (Therms)	Ex Post Gross Therms (Sample)	Spillover Rate
Central Hudson	74	14,544	0.5%
Con Edison	100	19,384	0.5%
Corning	97	6,453	1.5%
Enbridge	0	10,394	0.0%
National Fuel	136	46,569	0.3%
KEDLI	110	19,418	0.6%
KEDNY	78	19,024	0.4%
NiMo	143	50,507	0.3%
O&R	0	5,140	0.0%
		Statewide	0.3%

4.3.4 Distributor Perspective on Attribution

The majority of the interviewed distributors (5 out of 7) reported that the New York residential natural gas heating rebate programs have had a significant impact on their overall sales volume and the efficiency levels of the units they are selling. One distributor said his sales have grown "exponentially; every call that comes in people are asking if they are going to get a Con Edison rebate." Another distributor noted that his sales increased overall but that the rebate programs have also shifted sales towards natural gas heating equipment. Two interviewed distributors did not think that the programs had influenced the efficiency levels of equipment sold, noting that the rebates did not make up the price difference between the lower efficiency and higher efficiency units and that consumers were already purchasing energy efficient units.

The distributors who reported that the programs had influenced their sales were generally unable to quantify this influence.

All distributors stated that manufacturers are definitely offering more energy efficient heating equipment as a result of the HEHE programs. One distributor mentioned that at the beginning of these rebate programs, manufacturers could not supply the energy efficient equipment fast enough and there were shortages, but the manufacturers became more conscious of the increased demand for energy efficient heating equipment. One distributor noted that price is what drives demand for energy efficient equipment.

> *"When [consumers] look at purchasing equipment that is this costly, they aren't thinking about the energy efficiency or what they are doing to the environment but what it does to their pocketbook."*

A few of the distributors mentioned that if the rebates decreased, sales of energy efficient units would decrease as well. They believe if consumers do not have the incentive to purchase energy efficient equipment, they will go back to buying lower efficiency units.

Table A-13 provides a more comprehensive summary of results from the distributor interviews.

4.4 Incremental Cost

Based on responses to the contractor survey, we calculated incremental cost using two different methodologies:

1. Approach #1: We first calculated the mean and median installed cost for each efficiency level of a given measure. We then determined incremental cost by subtracting the mean (and median) installed cost of the standard efficiency equipment from the mean (and median) installed cost of the efficient equipment. We did this for each level of high efficiency for a given measure. This approach used all valid contractor responses, even if a contractor was only able to provide an estimate for a single efficiency level, but it led, in the case of furnaces, to internal inconsistencies in our incremental cost estimates.[67]

2. Approach #2: We first calculated incremental costs for each contractor and each efficiency level by subtracting the reported installed cost of the standard efficiency unit from the reported installed cost for the higher efficiency unit. We then combined the contractor-level results to develop statewide incremental cost statistics (minimum, maximum, mean, and median) for each rebate-eligible efficiency level. This approach only utilized responses from contractors who were able to provide installed costs for standard efficiency equipment. This approach solved the issue of internal inconsistency and has the additional advantage of producing a minimum and a maximum incremental cost value for each level of high efficiency for a given measure. However, it has the disadvantage of utilizing fewer responses and systematically excluding responses from contractors who do not install standard efficiency equipment (or could not provide a cost estimate for it).

Contractors reported a wide range of costs for all measures included in our analysis. Figure 4-1 below presents the mean, median, and range of incremental costs reported for each measure and efficiency level (based on analysis Approach #2). In some cases, the ranges of reported costs are very large.

[67] A substantial number of contractors reported costs for furnaces of 95% AFUE but did not report costs for furnaces of 94% AFUE. These contractors, on average, reported lower costs for 95% AFUE units than were reported for 94% AFUE units. As a result, the overall reported average cost for 95% AFUE units was lower than that for 94% AFUE units, leading to lower incremental cost estimates for 95% AFUE units compared to 94% AFUE units.

Figure 4-1. Estimated Incremental Costs

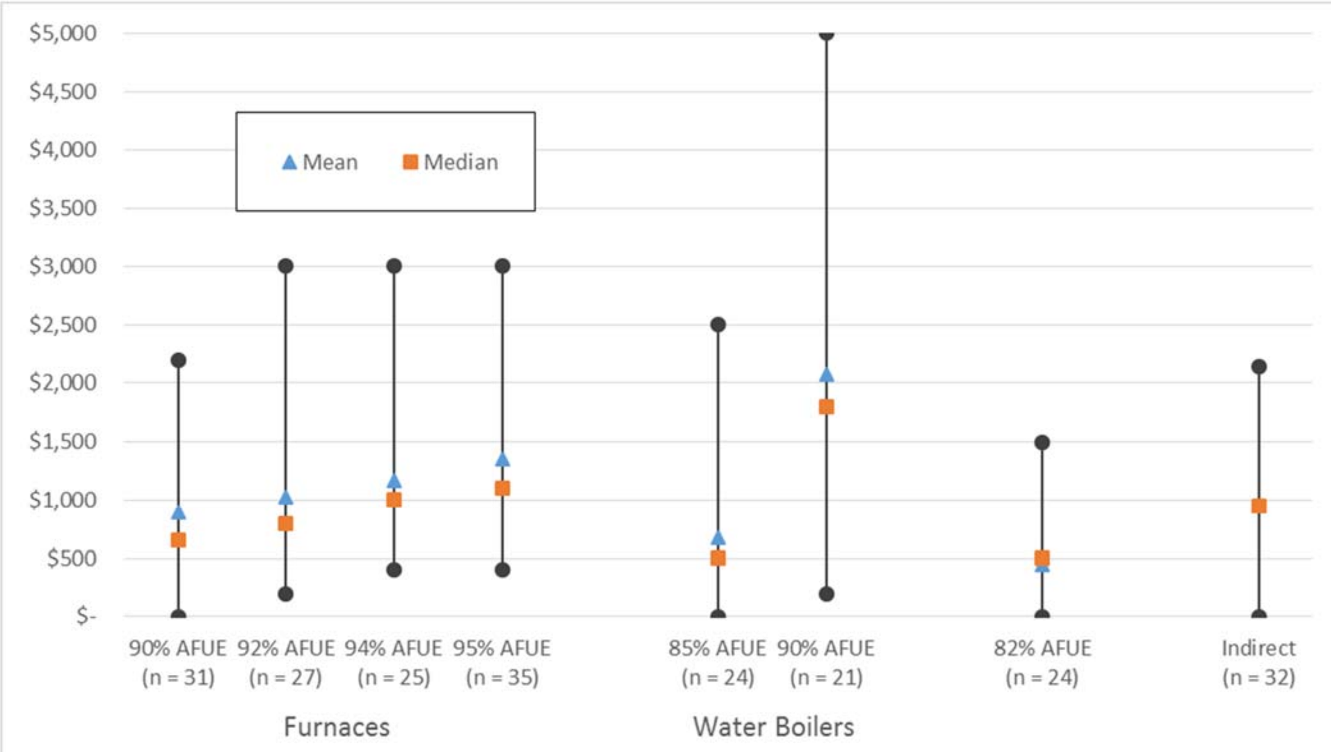

Table 4-22 provides the numeric values for the mean and median, for both analytical approaches. The table shows stable medians across both approaches. The means, on the other hand vary substantially for some measure-efficiency level combination, as a result of contractors that do not install standard efficiency equipment being excluded from Approach #2.

Table 4-22. Weighted Incremental Cost Estimates[A]

Measure	Approach #1			Approach #2		
	n	Mean	Median	n	Mean	Median
Furnace – 90% AFUE	46	$835	$700	31	$889	$650
Furnace – 92% AFUE	41	$1,062	$900	27	$1,022	$800
Furnace – 94% AFUE	35	$1,317	$1,200	25	$1,169	$1,000
Furnace – 95% AFUE	56	$1,295	$1,200	35	$1,349	$1,100
Water Boiler – 85% AFUE	25	$669	$500	24	$679	$500
Water Boiler – 90% AFUE	22	$2,073	$2,000	21	$2,072	$1,800
Steam Boiler – 82% AFUE	35	$130	$500	24	$442	$500
Indirect Water Heater	33	$955	$1,105	32	$944	$950

[A] Estimates of incremental cost are based on the total installed cost of equipment of different levels of efficiency; they include incremental costs for both equipment and labor.

Prior incremental cost assumptions provided by the PAs are presented in Table 4-23 below. These values come from a variety of studies with different focuses and have been updated at different times, which likely accounts for the large variability between them. We find our incremental cost estimates to be within the range of the prior PA values for most measures. The exceptions are 85% AFUE water boilers (for which contractors provided lower incremental cost) and indirect water heaters (for which contractors reported higher incremental cost), compared to prior PA assumptions.

Table 4-23. Prior PA Incremental Cost Assumptions

Measure Categories	KEDNY	KEDLI	NiMo	Central Hudson	National Fuel	Corning Gas	Con Edison[A]	O&R	Enbridge
Furnace ≥ 90% AFUE	-			$630	$1,000	-	$291	$1,150	-
Furnace ≥ 92% AFUE	$654 ($679 with ECM)			$802	-	-	$502 ($808 with ECM)	$1,458 (with ECM)	-
Furnace ≥ 94% AFUE with ECM	-			$1,226	-	-	$1,097	$1,915	-
Furnace ≥ 95% AFUE with ECM	-			$1,438	-	-	$1,097	$1,915	-
Water Boiler ≥ 85% AFUE	$984			$934	[D]	-	$884	$1,015	-
Water Boiler ≥ 90% AFUE	$1,310			$1,481	-	-	$4,018	$2,656[B]	-
Steam Boiler ≥ 82% AFUE	$2,186[C]			-	[D]	-	$286	-	-
Indirect Water Heater	$300			-	-	-	-	$302	-

- Indicates that PA did not provide incremental cost assumption.
[A] Con Edison estimates are for equipment only, with the exception of condensing boilers, which also include labor. This means that these estimates are biased downward for non-condensing boiler measures.
[B] Assumes 92% AFUE.
[C] NiMo provided a secondary estimate of $400.
[D] National Fuel provided incremental cost information for furnaces, water boilers, and steam boilers sourced from National Fuel's 2007 rate case testimony. Incremental costs for water boilers and steam boilers used different baseline assumptions than our analysis and are therefore omitted from this comparison.

5. Key Findings and Recommendations

Based on our analyses and the information presented above, we provide the following key findings and recommendations.

5.1 NYTM Review

- Air Sealing. The NYTM contains two algorithms for this measure. The algorithm that uses a blower door test is well specified. The second algorithm uses variables from a prototype. This type of approach typically provides savings that are reasonable if the prototype has been calibrated. From our review of the prototypes within the NYTM, this does not appear to have occurred; therefore the values within the NYTM may be biased either high or low. However, our billing analysis found a realization rate of 93% for this measure, indicating that the savings algorithms and assumptions used by the PAs provide a good estimate of actual savings.
  - We suggest that text around the NYTM algorithm used when blower door test data is available be modified to clarify the meaning of the term incorporating heat and distribution system efficiency.
- Boilers & Furnaces. We find the algorithm to be reasonable and comparable to those used elsewhere, but our billing analysis indicates that, if using NYTM default assumptions, the engineering algorithm overestimates savings. This overstatement can be attributed to NYTM default FLH values considerably higher than those produced in our billing analysis.
  - To better align future estimates of savings with actual values, we suggest the NYTM estimates of full-load hours be updated in accordance with this study, which will reduce expected savings to better align with the results of this billing analysis.
- Boiler Reset Controls. We find the algorithm for boiler reset controls to be well specified, with one exception: the algorithm assumes that multiple controls would increase the savings of a single boiler.[68] While different controls in commercial applications can control different systems, it is unclear how additional controls would provide additional savings for residential applications when the customer has only one boiler. Inputs to the algorithm are simple and well defined, and default values suggested for heating unit capacity when customer-specific data are not available are reasonable, with the exception of overstated full-load hour values.
  - We recommend clarifying the "units" variable in the NYTM algorithm for boiler reset controls to reflect that savings for only one control can be claimed for each boiler in the residential sector.
  - To better align future estimates of savings with actual values, we suggest the NYTM estimates of full-load hours be updated in accordance with this study, which will reduce expected savings to better align with the results of this billing analysis. However, if FLH values are not updated, we suggest additional research to verify ESF values could be valuable.

[68] During the DPS review process, the TecMarket team clarified that the "units" term in the boiler reset control algorithm refers to the number of controllers installed by the program. The evaluation team has added a recommendation that this be clarified in future versions of the NYTM.

- **Duct Sealing.** The NYTM algorithm is relatively similar to those used in other TRMs. However, it does not include a factor accounting for furnace efficiency, and therefore excludes interactive effects.
  - We suggest revising the NYTM algorithm to include a term accounting for furnace efficiency, and therefore interactive effects.
- **EC Motors.** The Wisconsin study upon which the deemed savings value is based includes savings in the summer and was conducted in an area of the country that most likely has a greater penetration of central air conditioning than New York. As such, the overall savings may be overstated. We do not have sufficient specific data to accurately adjust the NYTM deemed value.[69]
  - We recommend performing additional research into the parameters in the Wisconsin algorithm to more accurately quantify savings for the state of New York.
- **Indirect Water Heaters.** The NYTM includes an algorithm input called UA_{base} that can cause large changes in estimated savings, yet some of the specific inputs were not sourced. UA_{base} values for seemingly similar baseline water heaters in different NYTM sections vary substantially. In addition, the algorithm does not consider summer losses associated with IWHs that replace standard water heaters.
  - We suggest revising the information listed in the NYTM to specify more clearly the source of its assumptions. Alternatively, for larger-sized water heaters where stand-by loss data is available, more standardized estimates of UA_{base} could be used, such as the formula suggested by ASHRAE.
  - We recommend updates to the NYTM to more clearly explain the variation in UAbase values for seemingly similar baseline water heaters in different NYTM sections or, if necessary, to make values more consistent.
  - We also suggest to consider inclusion of a term to cover summer losses in the NYTM algorithm for indirect water heaters.
- **Programmable Thermostats.** This measure uses good engineering inputs, but may not accurately reflect how customers use their thermostats. We found the NYTM algorithm is simple and well defined, and default values suggested for heating unit capacity (when customer-specific data are not available) are reasonable. However, multiple recent evaluations[70,71] – as well as the billing analysis conducted in this current evaluation – have found lower-than-expected programmable thermostat savings, calling the 6.8% ESF used in the NYTM into question.
  - We suggest further research into the appropriate choice of ESF for programmable thermostats in New York. If further research aligns with recent findings, a change in the ESF specified may be necessary.

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[69] The full-load hour data that we do have for NY PAs averages to approximately 940 hours during the heating season (we did not have data for the cooling season). The Wisconsin study used 1,000 hours for the heating season and 400 hours for the cooling season. Because the heating FLH value was the only PA-specific number we had and it was relatively close to the Wisconsin number, we decided not to make any adjustments.

[70] *NYSERDA 2007-2008 EmPower New York℠ Program Impact Evaluation Final Report,* prepared for the New York Energy and Research Development Authority by Megdal and Associates. April 2012. Page ES-8.

[71] *NYSERDA 2007-2008 Home Performance with Energy Star® Program Impact Evaluation Final Report,* prepared for the New York Energy and Research Development Authority by Megdal and Associates. September 2012. Page 4-7.

5.2 Gross Impact Findings and Recommendations

The estimated statewide gross realization rate is 53%. The rate ranges from 50% for National Fuel to 68% for Corning. Applying the realization rate to total ex ante therm savings yields total ex post savings of almost 8 million therms.

Table 5-1. Summary of Gross Savings (2009-2011)

PA	Ex Ante Program Savings (Therms)	RR	Ex Post Program Savings (Therms)
Central Hudson	194,782	57%	111,406
Con Edison	863,985	52%	448,550
Corning	119,180	68%	81,531
Enbridge	91,348	61%	55,675
National Fuel	6,560,295	50%	3,264,486
KEDLI	955,067	61%	582,657
KEDNY	668,990	62%	416,473
NiMo	5,224,681	54%	2,797,021
O&R	325,988	63%	204,486
Statewide	15,004,317	53%	7,962,286

Statewide realization rates for program-incented measures range from 22% for thermostats to 93% for sealing. Realization rates for heating systems range from 60% to 69%. Thermostats have the biggest impact on overall realization rates. While they have relatively small per unit ex ante savings, they are the most frequently installed measure and have by far the lowest realization rate. Heating systems have the second biggest impact on overall ex post savings.

Table 5-2. Per Unit Gross Realization Rate Summary (2009-2011) [a]

<table>
<tr><th></th><th>Furnace with ECM</th><th>Furnace without ECM</th><th>Water Boiler</th><th>Steam Boiler</th><th>Indirect Water Heater</th><th>Boiler Reset Control</th><th>Thermostat</th><th>Sealing</th></tr>
<tr><th>Evaluation Method</th><th colspan="4">Post-Installation Billing and FLH Analysis</th><th>Engineering Analysis</th><th colspan="3">Pre/Post Billing Analysis</th></tr>
<tr><td>Central Hudson</td><td colspan="4">77%</td><td>23%</td><td rowspan="9">63%</td><td rowspan="9">22%</td><td rowspan="9">93%</td></tr>
<tr><td>Con Edison</td><td colspan="4">81%</td><td>10%</td></tr>
<tr><td>Corning</td><td colspan="4">75%</td><td>n/a [b]</td></tr>
<tr><td>Enbridge</td><td colspan="4">60%</td><td>n/a [b]</td></tr>
<tr><td>National Fuel</td><td colspan="4">59%</td><td>105%</td></tr>
<tr><td>KEDLI</td><td colspan="4">66%</td><td>191%</td></tr>
<tr><td>KEDNY</td><td colspan="4">66%</td><td>189%</td></tr>
<tr><td>NiMo</td><td colspan="4">61%</td><td>192%</td></tr>
<tr><td>O&R</td><td colspan="4">70%</td><td>87%</td></tr>
<tr><td>Statewide</td><td>62%</td><td>60%</td><td>65%</td><td>69%</td><td>52%</td><td>63%</td><td>22%</td><td>93%</td></tr>
</table>

[a] This table reflects per-unit gross realization rates that we developed through impact evaluation of records in the program-tracking database that had savings values. The final realization rates for a PA, measure, or program may be very slightly higher, to account for records in the program-tracking database that had missing savings values.

[b] Corning Gas and Enbridge St. Lawrence did not estimate savings from indirect water heaters in the program-tracking databases.

The following bullets summarize our findings and recommendations from the gross impact analysis.

- **Data collection and program tracking.** Some PAs used default values for necessary inputs to savings calculations (such as equipment capacity). Further, not all PAs were applying NYTM algorithms in the same manner. For example, each PA could choose FLH assumptions based on vintage and home type, and therefore each PA may have had different criteria for assigning these values. Some PAs used default values as inputs instead of household-specific values. These tracking differences have implications for realization rates.
  - We recommend that PAs continue to improve data collection and program tracking practices. We also recommend to consider adding a database “check” task into future evaluations to enable periodic review of data quality and ensure consistency in how algorithms are applied.
- **Selection of Baseline.** For this study, we defined the baseline as the federal standard. However, we note that definition of the baseline can significantly influence savings results. If the standard market practice baseline exceeds federal standards, our estimated ex post savings would be overstated. Determining the most appropriate baseline for each measure was outside the scope of this study.
  - Given the sensitivity of results to the selection of the baseline, we recommend future research into this issue.
- **Replacement on Failure versus Early Replacement.** Consistent with how PAs claim savings and the approved work plan, we evaluated savings based on an assumption of replacement on failure. However, we note that this assumption can significantly influence savings results because savings for equipment that is replaced early would be higher than savings for equipment replaced on failure, if

the replaced equipment is less efficient than the baseline. Evaluating savings based on early replacement was outside the scope of this study and was not feasible since PAs do not systematically track the efficiency and condition of the replaced equipment.

- We recommend that PAs track the efficiency and/or age of the replaced equipment and whether the equipment was still functioning at the time of replacement, if feasible. This would provide additional information on the extent to which early replacement is taking place.[72]

- **Savings Assumptions for Heating System Replacement.** Full load hours for heating system replacement estimated through this evaluation indicate that assumptions in the NYTM (for an average single-family home) may be overstated by as little as 16% to as much as 41%. If the FLH values estimated in this evaluation were applied to 2009-2011 ex ante savings, realization rates would be between 59-81%, depending on the PA.
  - We recommend additional dialogue with New York stakeholders (i.e., the PAs, the Technical Manual Review Committee, the DPS, and the TecMarket team) about potential updates to residential heating equipment FLH assumptions the NYTM, in light of increasing evidence from this evaluation and the NYSEG/RG&E HEHE Evaluation that current FLH assumptions are resulting in overstated ex ante savings.
  - If stakeholders wish to modify FLH assumptions for planning purposes, we would recommend applying an adjustment factor to FLH assumptions in the NYTM (see page 431 of the October 15, 2010 NYTM) based on the average difference between FLH assumptions in the NYTM and evaluated Ex Post FLH. For the five climate zones with more than 1,000 participants represented in our FLH analysis, we would recommend using climate zone-specific adjustments for each climate zone (see the last column of Table 5-3). For climate zones with less than 300 participants represented in our FLH analysis (Binghamton and Massena), we would recommend using an Upstate weighted average adjustment.

[72] If PAs choose to base savings on early replacement, Appendix M, Section 5 of the NYTM specifies the additional variables that the TecMarket team recommends be tracked in program databases.

Table 5-3. Differences between NYTM FLH assumptions and Ex Post FLH

NYTM Climate Zone	N	Ex Post FLH	NYTM Assumption for "Average Vintage" Single-Family Home		Recommended Adjustment
			FLH	Ex Post FLH % Difference	
NYC	2,513	786	934	-16%	-16%
Poughkeepsie	1,060	862	1,157	-26%	-26%
Buffalo	16,319	1,032	1,473	-30%	-30%
Albany	1,619	978	1,379	-29%	-29%
Syracuse	1,558	1,042	1,391	-25%	-25%
Binghamton	239	1,136	1,450	-22%	-29%[a]
Massena	266	889	1,496	-41%	-29%[a]
Statewide Average[b]	23,574	995	1,389	-28%	n/a
Downstate Average[b]	2,513	786	934	-16%	n/a
Upstate Average[b]	21,061	1,020	1,444	-29%	n/a

[a] Based on the Upstate average

[b] Weighted by the number of participants per climate zone in FLH analysis

- **Savings assumptions for Programmable Thermostats.** This evaluation showed that the current energy savings factor of 6.8% is not realistic among HEHE program participants. The realization rate for thermostat savings was 22%, and programmable thermostats appeared to save about 2% of average annual pre-installation natural gas consumption based on billing analysis.
  - Consider updating thermostat savings assumptions in the NYTM, taking into account program delivery. We understand that programmable thermostats may be installed through other delivery channels, and that savings may differ depending on the program population or delivery approach. As such, we recommend reviewing ex post savings observed in this and other evaluations or conducting additional research across multiple program designs (including this one) to determine if and how assumptions could be modified. For example, the results of this evaluation could be used to inform a revision for the HEHE Programs, while the results of other evaluation efforts could be used to update assumptions for other programs (e.g., home energy assessment) where programmable thermostats are installed.
- **Savings assumptions for Boiler Reset Controls.** While the realization rate for boiler reset controls was 63%, the pre/post billing analysis showed that actual percent savings are in line with the energy savings factor (ESF) in the NYTM.
  - We do not recommend action on this measure unless the NYTM FLH values are not updated (a reduction in those values would also reduce boiler reset control savings via the boiler reset savings algorithm).
- **Savings Assumptions for Indirect Water Heaters.** The current NYTM algorithm does not currently account for a reduction in operating efficiency during summer months. The decrease in efficiency would be applicable to households that switch from a standard natural gas-fired water heater to a

large boiler with an indirect hot water heater.[73] In addition, the NYTM also uses an algorithm to calculate the heat loss coefficient for the baseline water tank, but not all values in the algorithm are documented. The resulting heat loss coefficient is higher than most other sources and higher than the deemed heat loss coefficient for standard hot water heaters in other areas of the NYTM.

- While a decrease in efficiency during summer months will vary by household, depending on the baseline system type, we recommend incorporating data on system type (i.e., indirect water heater, individual natural gas boiler and storage water heater, etc.) in future evaluations to help inform what percent of the households would be impacted by this efficiency loss. Depending on the outcome of that analysis, consider incorporating summer losses into future impacts calculations for indirect water heaters. For the heat loss coefficient of the baseline water heater, consider updating the NYTM to consistently apply this factor across all measures that include a baseline hot water heater. Consider other references (e.g., ASHRAE) to ensure the deemed value is consistent with industry standards.

5.3 Net Impact Findings and Recommendations

The estimated statewide NTGR for the evaluation period (2009-2011) is 61.8%. We estimate free-ridership to be 38.5% and spillover 0.3%. The NTGR ranges from 71.0% for KEDLI to 48.2% for Orange & Rockland (O&R). Free-ridership ranges from just under 30% for KEDLI to approximately 50% for O&R, Corning, and Enbridge. Participant spillover is uniformly low across PAs, ranging from no spillover for Enbridge and O&R to 1.5% for Corning.

Table 4-17 summarizes the program-level FR, participant SO, and NTGRs.

Table 5-4. Program Level NTGRs

PA	Program Free-Ridership	Program Spillover	Program NTGR
Central Hudson	31.8%	0.5%	68.8%
Con Edison	36.5%	0.5%	64.1%
Corning	50.4%	1.5%	51.1%
Enbridge	47.8%	0.0%	52.2%
National Fuel	36.9%	0.3%	63.4%
KEDLI	29.6%	0.6%	71.0%
KEDNY	37.5%	0.4%	62.9%
NiMo	41.5%	0.3%	58.8%
O&R	51.8%	0.0%	48.2%
Statewide	38.5%	0.3%	61.8%

Table 4-18 below presents ex post net impacts for 2009 to 2011, by PA and statewide, calculated by multiplying ex-post gross impact results by the NTGR.

[73] Existing equipment is not tracked by PAs. Our analysis of IWH savings assumes that each new IWH replaced a standard water heater.

Table 5-5. Program Level Net Impacts (2009-2011)

PA	Ex-Post Gross Impacts (Therms)	Program Level NTGR	Ex-Post Net Impacts (Therms)
Central Hudson	111,406	68.8%	76,596
Con Edison	448,550	64.1%	287,313
Corning	81,531	51.1%	41,673
Enbridge	55,675	52.2%	29,057
National Fuel	3,264,486	63.4%	2,070,017
KEDLI	582,657	71.0%	413,603
KEDNY	416,473	62.9%	261,855
NiMo	2,797,021	58.8%	1,644,122
O&R	204,486	48.2%	98,639
Statewide	7,962,286	61.8%	4,922,876

5.4 Incremental Cost Findings and Recommendations

This evaluation included estimation of incremental costs for the four major measures incented through the Programs: furnaces, water boilers, steam boilers, and indirect water heaters. We estimated incremental costs for various efficiency levels, corresponding to efficiency levels rebated by the PAs through the Programs. Table 5-6 provides mean and median incremental cost estimates. Results are presented for two analytical approaches developed as part of this evaluation (described in more detail in Sections 3.4 and 4.4).

Table 5-6. Weighted Incremental Cost Estimates

Measure	Approach #1			Approach #2		
	n	Mean	Median	n	Mean	Median
Furnace – 90% AFUE	46	$835	$700	31	$889	$650
Furnace – 92% AFUE	41	$1,062	$900	27	$1,022	$800
Furnace – 94% AFUE	35	$1,317	$1,200	25	$1,169	$1,000
Furnace – 95% AFUE	56	$1,295	$1,200	35	$1,349	$1,100
Water Boiler – 85% AFUE	25	$669	$500	24	$679	$500
Water Boiler – 90% AFUE	22	$2,073	$2,000	21	$2,072	$1,800
Steam Boiler – 82% AFUE	35	$130	$500	24	$442	$500
Indirect Water Heater	33	$955	$1,105	32	$944	$950

Appendix A. Additional Methodology and Results

This appendix provides more detailed technical information for the various analyses of this evaluation.

Pre/Post Billing Analysis

This section describes the methodology and regression results for pre/post billing analysis.

General Model Specification

Upon completion of the data aggregation and cleaning effort, the evaluation team applied a generalized linear model with customer-specific intercept of the form shown in below:

$$C_{it} = \alpha_i + \tau_t + \sum_{j=1}^{p} x_{ijt}\beta_j + \sum_{k=1}^{q} z_{ikt}\gamma_k + \varepsilon_{it}$$

Where:

C_{it} is the monthly consumption for the household i in period t, expressed in monthly therms per day

α_i is the "customer-specific" intercept (or error) for household i, accounting for unexplained difference in use between households associated with the number of occupants, appliance holdings, and lifestyle

τ_t is the "time-specific" error for period t, reflecting the unexplained difference in use between time periods

x_{ijt} are the predictor variables reflecting the installation of energy efficiency measure j for household i in period t,

β_j are the slope coefficients that quantify the average influence of modeled efficiency measure j on monthly consumption

p is the total number of energy efficiency measures included in the model

z_{it} are the predictor variables reflecting non-program-related effect k (such as weather impacts) for household i in period t

γ_k represents the slope coefficients that quantify the average influence of modeled non-program-related effect k on monthly consumption

q is the total number of non-program-related effects included in the model

ε_{it} is the error term that accounts for the difference between the model estimate and actual consumption for household i in period t

The model used dummy variables, in which the x's for the installed measures are 1 or 0 to indicate the installation, and the coefficients reflect the savings for the measures and weather effects as predictor (independent) variables. We estimated program savings from modeled regression coefficients for program variables. This approach provides the gross savings realized by replacing the customers' existing equipment with new (i.e., rebated) equipment under the program. Savings calculated in this manner are expected to provide an upper boundary to actual savings when the HEHE program is evaluated in comparison to federal efficiency standards, as it is expected program participants will be replacing older, less-efficient equipment.

Considerations for Model Specification

Time Period Effects and Definition of the Pre- and Post-Periods

To estimate measure savings, the measure variables were interacted with a dummy variable (*post*), which defines the pre- and post-periods. All measure variables interacted with this dummy variable are set to 0 during the pre-installation period and 1 for the post-installation period. The pre-installation period was defined as all activity prior to the installation date recorded in the program-tracking data, and the post-installation period begins following the installation date. The billing cycle that included the installation (or the billing cycles, if multiple measures were installed at different times) was eliminated from the analysis on a house-by-house basis.

Weather Effects

The heating and cooling degree-day variables in the regression model were calculated based on the daily temperatures for each billing cycle. Temperature data was obtained from NOAA's National Climactic Data Center for the years 2003 to 2013, and these data were aggregated to obtain (a) the heating degree-days (base 65) for each billing cycle, and (b) 10-year averages. The weather station associated with each participant's home was assigned by ZIP code. The program and weather data were merged with the billing history for use in the regression model.

Calculation of Savings from Estimators

Savings for the non-temperature-dependent measures were estimated by the direct inclusion of a binary variable set to 0 during the pre-installation period and 1 during the post-installation period. The resulting estimators were in units of therms per day, and were multiplied by 365 days to calculate energy savings per year.

All measures designed to save space-heating energy use were modeled by estimating the heating slope for the post-installation period and the heating slope over the entire analysis period; the post-installation variable reflects the difference in heating slopes, and thus the savings. The resulting estimators were in units of therms savings per degree-day, and were multiplied by the 10-year average annual heating degree-days for the participants with the measure to calculate energy savings per year. Both variables were specific to the homes that received the measure, as this approach tends to improve the ability to estimate savings.

Model Selection among Alternative Models

A component of the modeling process is to compare alternative models to determine the model that best fits the data, and to assess the relative importance of specific variables or groups of variables. Standard statistics, such as the coefficient of determination (R^2) and t-values for specific parameters, were compared. In addition, the information-theoretic approach to model selection was employed to ensure that the selection of the final model is based on objective statistical standards.[74] This approach

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[74] In billing analysis, the analyst makes many decisions regarding the statistical characteristics of the model and the specific parameters to be included. Thus, there are typically a number of possible models that could be used to estimate savings.

was used in conjunction with a review of the modeling results to ensure that the "best model" in terms of the statistical properties also allowed for improved estimation of the variables of interest.

Table A-1. Candidate Models Evaluated

Model Number	Description	Variables
1	Base model	Simple grouping of measures into heating / base
2	Any heating system	Base plus single variable for any heating system, variables for reset control, thermostat, air sealing
3	Furnaces vs. boilers	Same as #2 above, but split heating systems into two general variables: furnace, boiler
4	Each measure as separate variable	Base plus ECM furnace, furnace, water boiler, steam boiler, reset control, thermostat, air sealing
5	Combine furnaces	Same as #4 above, but with ECM furnaces and other furnaces grouped together
6	PA-specific heating degree days	Same as #4 above, but calculate heating slopes across PA; attempt to refine heating slope by restricting comparison to similar geography
7	Remove suspected fuel switches	Filter out some participants based on poor dependency of natural gas consumption on weather data during pre-installation period (the impact of this model on water boiler savings is show in the last row of Table 4-13)
Final	Measure-level heating slopes	Calculate heating slopes for each measure across group; combination of #6 and #7 above, but attempt to refine heating slope by restricting to other homes installing the same measure(s)

A description of the final model specification is presented in section 3.2.2, Pre/Post Billing Analysis Methodology. Regression model output is presented below.

Pre/Post Model Regression Results

The final results from the pre/post model are summarized in Table A-2 below. All variables with t-values above ±1.8 are statistically significant at the 10% confidence level. Savings from all measures except the indirect water heaters meet this standard. The lack of a statistically significant estimator and instability in the model under different configurations indicated that the pre/post model could not be used to develop reliable savings for the indirect water heaters. Consequently, we used an engineering-based approach for calculating savings from these measures (see section 3.2.3 of this report).

The information-theoretic approach provides an objective framework for selecting the best model among a series of competing candidate models. Please refer to *Model Selection and Multimodel Inference* by Kenneth Burnham and David Anderson, Springer-Verlag, NY, 2002.

Table A-2. Pre/Post Billing Model Regression Results Summary

Measure	Number of Homes in Model	Regression Estimator	Unit of Estimator	Standard Error	t-value
ECM Furnace	14,376	(0.016)	Therms/heating degree-day	1.9	-53.6
Furnace	15,529	(0.020)	Therms/heating degree-day	1.8	-73.1
Water Boiler	3,934	(0.026)	Therms/heating degree-day	2.6	-60.8
Steam Boiler	974	0.022	Therms/heating degree-day	4.3	24.8
Reset control	489	(0.008)	Therms/heating degree-day	6.5	-7.1
Thermostat	25,083	(0.003)	Therms/heating degree-day	1.7	-12.3
Air sealing	41	(0.030)	Therms/heating degree-day	22.0	-8.2
Base Measures (IWH)	225	(0.025)	Therms/day	12.7	-0.9
Extra Use (Fuel Switches)	2,542	0.112	Therms/heating degree-day	2.9	215.1

The table below details parameter estimates for all terms in the model. The highlighted section indicates the estimators summarized in the table above.

Table A-3. SAS Regression Output for the Pre/Post Model

Dependent	Parameter	Estimate	Std. Error	t-Value	p-value
ADCthm	ctime1	0.1172	0.2092	0.56	0.5753
ADCthm	ctime2	-0.2218	0.1103	-2.01	0.0443
ADCthm	ctime3	-0.1577	0.1101	-1.43	0.152
ADCthm	ctime4	-0.0945	0.1100	-0.86	0.3899
ADCthm	ctime5	0.0685	0.1099	0.62	0.5331
ADCthm	ctime6	0.1530	0.1099	1.39	0.1637
ADCthm	ahdd	0.1568	0.0005	320.3	<.0001
ADCthm	ahdd*dhfurn	-0.0204	0.0005	-41.01	<.0001
ADCthm	ahdd*dhecmfurn	-0.0149	0.0005	-30.14	<.0001
ADCthm	ahdd*dhwatboil	0.0223	0.0006	38.2	<.0001
ADCthm	ahdd*dhstmboil	0.0690	0.0009	78.38	<.0001
ADCthm	ahdd*dhresetcont	0.0237	0.0010	22.81	<.0001
ADCthm	ahdd*dhtstat	-0.0020	0.0002	-7.95	<.0001
ADCthm	ahdd*dhsealing	0.0122	0.0032	3.87	0.0001
ADCthm	ahdd*dextrause	-0.1274	0.0007	-191.37	<.0001
ADCthm	ahdd*dhfurn*POST	-0.0199	0.0003	-73.08	<.0001
ADCthm	ahdd*dhecmfurn*POST	-0.0155	0.0003	-53.63	<.0001
ADCthm	ahdd*dhwatboil*POST	-0.0257	0.0004	-60.82	<.0001
ADCthm	ahdd*dhstmboil*POST	0.0217	0.0009	24.76	<.0001
ADCthm	ahdd*dhresetcon*POST	-0.0083	0.0012	-7.05	<.0001
ADCthm	ahdd*dhtstat*POST	-0.0032	0.0003	-12.3	<.0001
ADCthm	ahdd*dhsealing*POST	-0.0296	0.0036	-8.23	<.0001
ADCthm	POST*diwhonly	-0.0253	0.0349	-0.73	0.4682
ADCthm	ahdd*dextrause*POST	0.1116	0.0005	215.03	<.0001

Diagnostics

The regression methods are based on the assumptions that the error term is independent, has a constant variance, and is normally distributed. Regression diagnostics were conducted for the final models (natural gas) to determine whether there were any major deviations from these assumptions. The effects of heteroskedasticity (unequal variances), collinearity, autocorrelation (lack of independence among observations), and influential data points were assessed as part of the model diagnostics.

Heteroskedasticity and autocorrelation do not result in biased estimators; rather, they affect the reported variability of the model. These two effects, both of which are likely to be present in the billing models, tend to have opposite impacts, with heteroskedasticity increasing the estimated error in the model and autocorrelation decreasing it.

Heteroskedasticity is often caused by the wide fluctuations between high-use and lower-use homes, and results in estimates showing higher variability than actually exists. The Goldfeld-Quandt test statistic was used to test for heteroskedasticity. This test statistic was 1.75 for the final model; a value higher than 1 suggests that heteroskedasticity may exist.

The models were also tested with and without outliers. Influential data points, or outliers, were determined using a DFFITS statistic, which is a scaled measure of change with and without an observation. The cut-off level was modified, as recommended by Belsley, Kuh and Welsch.[75] The DFFITS values were summed by household to identify homes that are outliers.

Once detected, the outlier households were removed and the regression analysis was run again to assess their impacts on the results. Using this method, 1,357 homes were identified as outliers in the model. The high number of outliers is an expected result of the large number of participants included in the model and the resulting low error bounds of regression variable estimates. Removing outliers from the model did not result in any significant change, indicating the stability of the regression estimators. Because the full models more correctly account for all of the program effects, the final estimates were based on the full models.

Autocorrelation is typically an issue in this type of billing model, as use in one month is closely related to consumption in the following month within each home. The effect of autocorrelation is to reduce the variability in the model (*i.e.*, the savings estimates appear to be less variable than they actually are). In a cross-sectional time series such as this, the pooled Durbin-Watson test is commonly used to assess the presence of autocorrelation. The pooled Durbin-Watson test statistic was found to be 0.679, indicating the data set is autocorrelated. This result was expected, as energy consumption on the household level in one month is generally closely related to the energy consumption in the previous month. As discussed above, autocorrelation does not impact our coefficient estimates. Rather, it affects the standard errors.[76]

Collinearity refers to the situation where two or more independent variables in a model are highly correlated, such as when two measures tend to be installed together. Collinearity results in higher variances for both predicted and explanatory variables, and tends to result in instability in the model

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[75] This adjustment was set at 2 x square root (p/n), where p is the number of variables and n is the number of observations. Belsley, D.A., Kuh, E., and Welsch, R.E. *Regression Diagnostics*, New York: John Wiley & Sons, Inc., 1980.

[76] In this case, the standard errors reflect the variability in the model. As there was no sampling, there is no sampling error associated with this analysis.

estimators (*i.e.*, large swings in the magnitude of the estimators depending upon the variables included in the model), and may result in estimators of the wrong sign (*i.e.*, estimators indicating that a measure results in an increase in use rather than savings). Variables were carefully defined to avoid collinearity.

The results of the regression diagnostics suggest that the estimated savings from the natural gas pre/post model are reliable and stable.

Weather Data Used in Analysis

Table A-4. Weather Stations used in NYSG HEHE FLH Analysis

Airport	WMO ID	State	Percentage of Participants[a]	10-Year Average HDD65[b]	TMY3 HDD65
Buffalo Niagara International Airport	725280	NY	34%	6,417	6,579
Albany County Airport	725180	NY	12%	6,429	6,648
Syracuse Hancock International Airport	725190	NY	10%	6,438	6,529
Niagara Falls AFB	725287	NY	9%	6,548	6,396
New York J F Kennedy International Airport	744860	NY	6%	4,760	4,874
Republic	744864	NY	4%	5,068	4,839
Utica Oneida County Airport	725197	NY	4%	6,927	6,898
Jamestown (Awos)	725235	NY	3%	7,115	7,199
White Plains Westchester Co A	725037	NY	3%	5,464	5,751
New York Laguardia Airport	725030	NY	2%	4,436	4,401
Glens Falls Airport	725185	NY	2%	7,386	7,023
Newark International Airport	725020	NJ	2%	4,647	5,030
New York Central Park Observatory	725033	NY	2%	4,605	4,957
Islip Long Island Macarthur Airport	725035	NY	2%	5,230	4,966
Elmira Corning Regional Airport	725156	NY	1%	6,794	6,423
Stewart Field	725038	NY	1%	5,652	6,081
Bradford Regional Airport	725266	PA	1%	7,631	8,049
Poughkeepsie Dutchess Co Airport	725036	NY	1%	5,917	5,902
Teterboro Airport	725025	NJ	1%	4,776	4,803
Westhampton Gabreski Airport	744865	NY	<1%	5,532	5,402
Rochester Greater Rochester I	725290	NY	<1%	6,404	6,462
Massena Airport	726223	NY	<1%	7,844	7,828
Watertown Airport	726227	NY	<1%	7,399	7,189
Fort Drum/Wheeler-Sack	743700	NY	<1%	7,489	7,391
Monticello (Awos)	725145	NY	<1%	6,859	7,010
Caldwell/Essex Co.	724094	NJ	<1%	5,263	5,022
Groton New London Airport	725046	CT	<1%	5,612	5,590
Binghamton Edwin A Link Field	725150	NY	<1%	6,927	6,992
North Adams	725075	MA	<1%	6,785	6,547
Danbury Municipal	725086	CT	<1%	6,036	6,031
Adirondack Regional	726228	NY	<1%	9,115	8,799
Burlington International Airport	726170	VT	<1%	7,203	7,299

[a] This column reflects the distribution among all 2009-2011 HEHE program participants, not just the participants in billing analysis.

[b] Source: National Climatic Data Center, Climate Data Online. 2003-2012.

Detailed Free-Ridership Methodology

Free-riders are program participants who would have implemented the incented energy-efficient measure(s) even without the program. In other words, free-ridership (FR) represents the percent of savings that would have been achieved in the absence of the program.

The goal of most incentive-based energy efficiency programs is to influence customer decision-making regarding energy-efficient improvements. Programs can do this by changing *what* customers install, *when* they install it, and *how much* they install. In other words, programs influence the *efficiency, timing,* and *quantity* of customers' energy-using equipment installations.

The bulk of program savings is typically achieved by encouraging customers to install higher-efficiency equipment than they would have installed on their own. Programs may also encourage early replacement of still-functioning equipment that is less efficient, thus impacting the timing of the installation, so savings can be realized earlier. The incentive may also make it more affordable for customers to install a greater number of high-efficiency measures. As such, the free-ridership algorithm outlined here combines the estimates of each of these concepts:

- Program influence on the efficiency level of the installed equipment (EI)
- Program influence on the timing of the installation of high-efficiency equipment (TI)
- Program influence on the quantity of the high-efficiency equipment installed (QI)

As part of its activity in the market, the program can provide information, training, and other support to contractors, thus potentially influencing the way contractors recommend HVAC equipment to customers. This program outreach and the interactions with contractors might not necessarily be visible to program participants; as such, FR estimates based only on participant feedback might not accurately reflect the true credit that the program deserves. To address this gap, telephone interviews with contractors will be used to adjust the participant-derived FR rates to account for the broader influence of the program on the market that might not be visible to participants.

Initial Free-Ridership Estimation through Participant Research

Telephone interviews with participants were used to develop the basis of the free-ridership score. We based the score on a series of questions designed to gather data on the customer's preexisting plans to implement the program measure, willingness to have bought the measure even if there was no program incentive (i.e., to pay full cost), and likelihood of taking the same action in the absence of the program.

Efficiency (EI), timing (TI), and quantity (QI) of the installation are distinct avenues of program influence. However, the timing of the installation and quantity of measures installed are conditional on efficiency. The program can only realize timing savings if the customer would have installed the efficient equipment on their own but the program caused the installation to happen earlier. Similarly, savings due to a quantity increase can only happen if a customer who was already installing some energy-efficient measures chooses to install additional measures because of the program.[77]

[77] Because the amount of duct and air sealing is not easily quantifiable for respondents, the free-ridership algorithm omits the quantity component for this measure.

We believe that when the three concepts are measured as distinct yet conditional methods of program influence, it is appropriate to account for each one. Multiplication and averaging are appropriate approaches to achieve that. To arrive at the free-ridership score, we will combine the EI and QI scores multiplicatively. We will then average this product with the TI score, but only in cases when the timing score does not exceed the product of multiplying the EI and QI scores. In cases where the timing score exceeds the product of EI and QI, the FR rate is based on just the product of the EI and QI scores. This selective averaging is important so the program is not penalized for having a smaller influence on the timing of the purchase than the efficiency and size of the purchase. In addition, the timing and quantity scores will only be included in the algorithm if EI ≥ 0.50 (i.e., there is a reasonable likelihood that high-efficiency equipment would have been installed at all, in the absence of the program).

$$IF\ EI \geq 0.50\ AND\ TI \leq (EI*QI),\ THEN\ FR = AVERAGE((EI*QI);TI)$$

$$IF\ EI \geq 0.50\ AND\ TI > (EI*QI),\ THEN\ FR = EI*QI$$

$$ALL\ OTHER\ CASES,\ FR = EI$$

Below is further detail on how each influence score was calculated, as well as the survey questions measuring each area of influence.

Program Influence on Equipment Efficiency (EI)

Based on our knowledge of the program theory, the following program components can be of influence on the customer decision-making process to install high-efficiency equipment:

- Program rebates (EI1)
- Program marketing (EI2)

A seven-point scale (1-7) will be used to measure each of the program components. Opinions in the industry on the use of various rating scales vary. However, there is research providing evidence that seven-point scales yield more reliable and valid results than other types of scales.[78]

Survey responses to the efficiency influence questions will be converted from the seven-point scale to a value between 0 and 1 using linear transformation. For example, a response of 3 on a seven-point scale will become 0.33 or 0.66, depending on how the anchor points of the scale will be defined to respondents. Table A-5 below provides an example of the linear transformation of a seven-point scale to a value between 0 and 1.

[78] Lozano, M., García-Cueto, E., Muñiz, J. 2008. "Effect of the Number of Response Categories on the Reliability and Validity of Rating Scales." European Journal of Research Methods for the Behavioral and Social Sciences 4(2): 73-79.

Table A-5. Example of Linear Transformation of the Scale Responses

Scale	Equation for Linear Transformation of the Scale Responses	Result of the Linear Transformation of the Scale Responses
1	(1-1)/6	0
2	(2-1)/6	.167
3	(3-1)/6	.333
4	(4-1)/6	.5
5	(5-1)/6	.667
6	(6-1)/6	.833
7	(7-1)/6	1

We do not have any reason to believe that linear transformations would yield results that are less reliable or valid than if we were to use non-linear transformations of the scale responses. The linear transformation approach also seems intuitive, given the use of a numeric scale with bounded endpoints. We therefore selected to use it in our calculations.

Because program rebates are considered the core program component, their influence was measured through more than one question to ensure reliability of results, with the results averaged to arrive at the overall influence of program rebates on equipment efficiency level.

The score for program influence on efficiency level of the equipment (EI) is the minimum rating across 1) the overall program rebate score, and 2) the program marketing score. This allows for the program to claim the credit for the most influential of its components on the respondent decision-making process. The resulting score will take a value from 0 to 1 expressed in terms of free-ridership, with 1 being a full free-rider (no program influence) and 0 being not a free-rider (maximum program influence).

Questions:

FR4. *Using a scale of 1 to 7, where 1 means no influence and 7 means a great deal of influence, please rate the influence of the following on your decision to install the* [READ IN "HIGH EFFICIENCY" IF MEASURE TYPE = FURN, STM, WTR] *<MEASURE>. (If needed: Using a scale of 1 to 7, where 1 means no influence and 7 means a great deal of influence, please rate the influence of this factor on your decision to install the* [READ IN "HIGH EFFICIENCY" IF MEASURE TYPE = FURN, STM, WTR] *<MEASURE>)*

- *a.* *Contractor recommendations*
- *b.* *[ASK IF Q2B=1 OR Q2C=1] Information from <PROGRAM ADMINISTRATOR>'s marketing materials [IF Q2C=1, READ "AND WEBSITE"]*
- *c.* *The <PROGRAM ADMINISTRATOR> rebate*

FR9. How likely is it that you would have installed [READ IN "THE SAME EFFICIENCY HEATING EQUIPMENT" IF MEASURE TYPE = FURN, STM, WTR] [READ IN "THE <MEASURE>" IF MEASURE TYPE = TSTAT, RESET, SEAL, IWH] if you had not received a rebate from <PROGRAM ADMINISTRATOR>? Please use a 1 to 7 point scale where 1 is "not at all likely" and 7 is "very likely."

Calculation:

EI = MIN(EI1; EI2)

Where:

EI1 = MEAN(1-(FR4c-1)/6; (FR9-1)/6)

EI2 = 1-((FR4b-1)/6)

Program Influence on Timing (TI)

Program influence on timing was measured by asking participants if the purchase/installation would have happened later in the absence of the program, and if so, how much later, with the resulting score taking a value between 0 and 1. The timing score ranges from 0 to 1 based on when participants report the equipment installation would have taken place without the program. Similar to the efficiency score, the timing score will be expressed in terms of free-ridership, with 1 being a full free-rider (no program influence) and 0 being not a free-rider (maximum program influence).

Questions:

FR5. Did the availability of the <PROGRAM ADMINISTRATOR> rebate cause you to install your [READ IN "HIGH EFFICIENCY" IF MEASURE TYPE = FURN, STM, WTR] <MEASURE> EARLIER than you were planning, or did the rebate have no influence on when you installed the equipment?

[IF CAUSED TO INSTALL EARLIER]

FR7. If the <PROGRAM ADMINISTRATOR> rebate had not been available, when would you have installed your [READ IN "HIGH EFFICIENCY" IF MEASURE TYPE = FURN, STM, WTR] <MEASURE>? Would you say...

Within 6 months of when you did
6 months to a year later
1 to 2 years later
More than 2 years later

Calculation:

TI = 1 IF FR5=NO OR (FR5=YES AND FR7=WITHIN 6 MONTHS)

TI = 0.66 IF FR5=YES AND FR7=6 MONTHS TO YEAR LATER

TI = 0.33 IF FR5=YES AND FR7=1 TO 2 YEARS LATER

TI = 0 IF FR5=YES AND FR7=MORE THAN 2 YEARS LATER

Participants receive a free-ridership score of 0 if they 1) responded to FR5 that they were not planning on installing the equipment *at all* without the rebate (this is an unprompted response) and 2) confirmed this response in FR6. If they respond this way, and previously responded that the rebate was less than very important to their decision, they received a consistency check (FR10).

Program Influence on Quantity (QI)

Program influence on quantity was measured by asking participants who purchased/installed more than one piece of equipment if they would have purchased/installed fewer without the program. The quantity score was calculated by dividing the quantity that they would have purchased absent the program by the program-rebated quantity. As such, the score will take a value between 0 and 1. Similar to the efficiency and the timing scores, the quantity score will be expressed in terms of free-ridership, with 1 being a full free-rider (no program influence) and 0 being not a free-rider (maximum program influence).

Questions:

FR8. If the <PROGRAM ADMINISTRATOR> rebate had not been available, would you still have installed <QUANTITY> [READ IN "HIGH EFFICIENCY" IF MEASURE TYPE = FURN, STM, WTR] <MEASURE> or would you have installed fewer?

[IF FEWER]

FR8a. How many <MEASURE> would you have installed if the rebate had not been available?

Calculation:

QI=1 IF FR8=THE SAME QUANTITY

QI=FR8A/PROGRAM QUANTITY IF FR8=FEWER

Additional Questions

Consistent with DPS guidelines, the participant survey included set-up questions, questions to rule out rival hypotheses, and questions to check the consistency of participant responses. A description of the consistency check process is provided below.

Confirmatory Questions and Consistency Checks

The scoring algorithm relies on responses from multiple questions to determine the free-ridership rate. Because respondents can sometimes give inconsistent answers, the survey instrument included confirmatory questions and consistency checks to clarify and validate these responses. For respondents that gave inconsistent responses, we reviewed free-ridership scores based on their responses to open-ended consistency check questions. In this process, two trained Opinion Dynamics professionals independently reviewed responses to survey questions that triggered a consistency check, and adjusted them if warranted, based on original answers and open-ended responses to consistency check questions. These adjusted scores were then averaged and used in lieu of the original respondent answers to these questions.

Confirmatory Questions:

FR6. Just to confirm, if the <PROGRAM ADMINISTRATOR> rebate had not been available, you would NOT have installed your <MEASURE> at all, is that correct?

Consistency Checks:

FR10. Just to make sure I understand, please explain the importance of the rebate you received from <PROGRAM ADMINISTRATOR> on your decision to install the [READ IN "HIGH EFFICIENCY" IF MEASURE TYPE = FURN, STM, WTR] <MEASURE> [READ IN "INSTEAD OF LESS EFFICIENT EQUIPMENT" IF MEASURE TYPE = FURN, STM, WTR].

Free-Ridership Adjustment through Contractor Research

As part of its activity in the market, the program can provide information, training, and other support to contractors, thus potentially influencing the way they recommend energy-efficient equipment to customers. This program outreach and the interactions with contractors might not necessarily be visible to program participants. As such, FR estimates based only on participant feedback might not accurately reflect the true credit that the program deserves.

To address this gap, we completed 54 telephone interviews with contractors whom participants identified as influential in their decision to install high-efficiency heating equipment.[79] As part of the interviews, contractors were asked a series of questions about their knowledge and interactions with the program, program influence on their stocking and sales practices, and customer decision-making processes. These responses were used to adjust the participant-derived FR rates to account for the broader influence of the program on the market that might not be visible to participants.

The results of the participant survey were used as the basis for the FR score. The adjustment of participant-derived FR score is comprised of following three steps:

- **Setting the maximum possible FR adjustment score using participant data.** Using the participant survey results, we determined the maximum possible adjustment to the FR score due to program influence on contractors.
- **Determining the influence of the program on participating contractors and the FR adjustment score.** Through our interviews with contractors, we estimated the influence the program had on their stocking and sales practices and created an adjustment score.
- **Determining the final FR score.** We then applied the adjustment score to FR scores of participants who had identified contractors as influential in their decision to install high efficiency heating equipment to arrive at the final FR rate.

Setting the Maximum Possible FR Adjustment Score

The participant FR score is derived using the approach outlined above (not including contractor adjustment) and can be considered the maximum FR score (Unadjusted Participant FR). It accounts for program influences visible to participants, such as incentives and marketing, but does not account for possible program influence on contractor recommendations that are not often visible to participants, making it impossible for participants to assess accurately. However, participants can assess the influence their contractor had on their decision to install high-efficiency equipment.

As part of the participant survey instrument, we asked participants about the influence contractor recommendations had on their decision to select high-efficiency measures. Using participant responses to this question, we developed the lower bound of the FR score (MIN FR). We do this by

[79] We attempted a census of all contractors in our sample. Therefore, concepts of sampling error and precision do not apply.

setting the participant's FR score to 0 for those participants who rated the influence of their contractor a 6 or 7 on the seven-point scale. This initial step assumes that contractor influence equates to program influence; the resulting MIN FR represents the lower bound below which the participant FR score cannot be reduced. In other words, by resetting participant FR scores, we are assuming that any respondent that was significantly influenced by the contractor was influenced by the program to the degree that gives the program full credit.

Using the Unadjusted Participant FR and MIN FR values, we computed the maximum possible FR adjustment score (MAX ADJ):

MAX ADJ = Unadjusted Participant FR - MIN FR

Determining the Influence of the Program on Participating Contractors

During this step, we estimated the influence of the program on contractors. Although the program attempts to get contractors to recommend more energy efficiency equipment, it is likely that a number of factors influenced contractor recommendations. We used the results of contractor interviews to determine the influence of the program on contractors, and as a result, how much of the maximum FR adjustment score (MAX ADJ derived above) the program can reasonably claim. In other words, during this step we determined the true adjustment score (ADJ).

We relied on multiple questions to determine the degree of program influence on how contractors approach recommending equipment for a specific project. Based on the survey questions, we determined two scores of program influence that we then averaged together to arrive at the true influence score (*I*). The first influence score will explore individual indicators of changes that can effectively contribute to recommendations of high efficiency equipment and program influence on each. The second influence score will explore an increase in recommendations of high efficiency equipment and the degree of program influence on increase. The two influence scores are combined by taking an average. Because the two influence scores will measure similar concepts, averaging across them is appropriate.

I=AVERAGE(I1,I2)

We only asked program influence questions of those contractors that were identified by participants (in question FR4a) as having been influential in their decision to install high-efficiency equipment (i.e., an influence score of 6 or 7 on the seven-point scale).

Influence 1 (I1)

To develop this score, we asked contractors to rate the degree of change between 2009 and 2011 in each of the following:

- Knowledge of high-efficiency options
- Comfort level with discussing the benefits of high-efficiency equipment
- Confidence level with recommending high-efficiency options

If at least a little bit of change was reported for any of the above, we followed-up with questions asking contractors to rate the influence of the program on the degree of change. A seven-point scale (1-7) was used to measure each degree of program influence. Survey responses to both the degree of change that occurred in each area and program influence on the change were converted to a value between 0 and 1 using linear transformation. We adjusted the degree of program influence on the change by the degree of change. The final score takes a value between 0 and 1, where 0 is no program attribution and 1 is full program attribution. The program receives credit for the factor it influenced the most.

<u>*Questions:*</u>

FR1. Since the <PA>'s gas rebate program began in 2009, how have the following four aspects changed. For each, please tell me if it improved greatly, improved somewhat, improved a little, or did not improve. [1=IMPROVED GREATLY, 2=IMPROVED SOMEWHAT, 3=IMPROVED A LITTLE, 4=DID NOT IMPROVE, 8=DON'T KNOW, 9=REFUSED]

a. Your knowledge of high efficiency options

b. Your comfort level with discussing the benefits of high efficiency with your customers

c. Your confidence level in recommending high efficiency options

[ASK IF FR1a=1,2,3]

FR2. Now, using a scale of 1 to 7, where 1 is not at all influential and 7 is very influential, how influential ...

a. was THE PROGRAM on increasing your knowledge of high efficiency options?

[ASK IF FR1b=1,2,3]

FR3. How influential ...

a. was THE PROGRAM on increasing your comfort level with discussing the benefits of high efficiency with your customers?

[ASK IF FR1c=1,2,3]

FR4. How influential ...

a. was THE PROGRAM on increasing your confidence level in recommending high efficiency options?

<u>*Calculation:*</u>

I1=AVE(I1A, I1B, I1C)

IF FR1A=4, I1A=0, ELSE I1A=(1-((FR1A-1)/3))*((FR2A-1)/6)

IF FR1B=4, I1B=0, ELSE I1B=(1-((FR1B-1)/3))*((FR3A-1)/6)

IF FR1C=4, I1C=0, ELSE I1C=(1-((FR1C-1)/3))*((FR4A-1)/6)

Influence 2 (I2)

To develop this score, we asked contractors if there was an increase in sales situations where they recommend high-efficiency equipment options between 2009 and 2011. If an increase was noted, we followed-up with questions about the degree of increase in percentage terms. We further asked about the degree of program influence on that percentage. A seven-point scale (1-7) was used to measure each degree of program influence. We adjusted the degree of program influence on the change by the percent change. The final score takes a value between 0 and 1, where 0 is no program attribution and 1 is full program attribution.

<u>*Questions:*</u>

FR7. Since <PA>'s Gas Heating program began in 2009, has the frequency with which you recommend high efficiency <MEASURE> increased, decreased, or stayed the same?

1. Increase

2. *Decrease*
3. *Stay the same*
8. *(Don't know)*
9. *(Refused)*

[ASK IF FR7=1]

FR8. Approximately, what was the percent increase? [RECORD PERCENT 0% TO 100%; 998=DON'T KNOW; 999=REFUSED]

[ASK IF FR8>0%]

FR9. On a scale of 1 to 7, where 1 is not at all influential and 7 is very influential, how influential was the <PA>'s Gas Heating program in the increase? [1-7; 8=DON'T KNOW; 9=REFUSED]

<u>Calculation:</u>

IF FR7=1 OR 3, I2=0

IF FR7=2, I2=FR8*(FR9-1)/6)

We developed influence scores (*I*) as described above for each contractor. The overall contractor influence score is a weighted average of individual contractor scores by known evaluated savings that each contractor contributed to the program.

Similar to the participant survey, throughout the contractor survey instrument, we employed consistency checks and questions to eliminate rival hypotheses per DPS guidelines. The contractor survey instrument used extensive set-up questions that set the mind of the contractor to think about how they go about recommending heating equipment.

<u>Ruling Out Rival Hypotheses</u>

The survey defines non-program factors as factors including changes in codes and standards, customers requesting specific equipment, increased customer awareness, federal tax rebates and credits, and other factors not related to the program. We first ask how influential non-program factors were on the contractor's practices of recommending high-efficiency equipment:

<u>Influence 1</u>

FR2. Now, using a scale of 1 to 7, where 1 is not at all influential and 7 is very influential, how influential ...

b. were OTHER NON-PROGRAM factors on increasing your knowledge of high efficiency options?

FR3. How influential ...

b. were OTHER NON-PROGRAM factors on increasing your comfort level with discussing the benefits of high efficiency with your customers?

FR4. How influential ...

b. were OTHER NON-PROGRAM factors on increasing your confidence level in recommending high efficiency options?

Influence 2

FR10. And how influential were the other factors not related to the program in the increase? Please use a scale of 1 to 7, where 1 is not at all influential and 7 is very influential. [1-7; 8=DON'T KNOW; 9=REFUSED]

If both the program and non-program factors were influential in the participant's decision to install high-efficiency equipment, we will ask an open-ended question to explain the influence of the program.

Influence 1

FR6. You mentioned that both the program and other non-program factors were of influence on [LIST RESPONSE CATEGORIES WITH DISCREPANT RATINGS FROM FR2 THROUGH FR5]*. Please explain in your own words what was the influence of the program.*

Influence 2

FR11. You mentioned that both the program and other non-program factors were of influence in increasing the frequency with which you recommend high efficiency <MEASURE>. Please explain in your own words what the influence of the program was. [OPEN END]

While the questions about non-program factors do not directly enter the FR adjustment score, they do trigger the open-ended follow-up questions. We used these open-ended questions to make adjustments to the contractor responses, where warranted, to the program influence questions. This process was similar to the participant survey adjustments: Two trained Opinion Dynamics professionals independently reviewed responses to survey questions that triggered a consistency check, and adjusted them if warranted, based on original answers and open-ended responses to consistency check questions. No major changes were made to contractor scores based on open-ended responses.

Determining the Final FR Score

Because we know that the program cannot reasonably claim to have influenced every contractor, and that all contractors do not influence customers equally, we used the results of contractor interviews to determine how much of the maximum FR adjustment score (from the participant survey) the program can reasonably claim. The final influence score (I) takes the form of a value between 0 and 1, representing the percentage of influence the contractor attributes to the program in their sales of high efficiency heating equipment. We calculated final influence scores for each of the three PA groups we analyzed.

For each participant who identified their contractor as influential in their decision to install high-efficiency heating equipment, we then applied the group-specific contractor influence score to individual participant FR scores using the following formula:

$$ADJ\ FR = FR * (1 - I)$$

The formula above multiplies the unadjusted individual free-ridership score by the inverse of the influence score. If a contractor attributes 100% of their decision-making process around selling high-efficiency heating equipment to the program, participants who identified their contractor as being influential in their decision to install a high-efficiency heating system receive a free-ridership score of 0. Alternatively, if a contractor attributes 0% of their decision-making process around selling high-efficiency heating equipment to the program, participants who identified their contractor as being influential in their decision to install a high-efficiency heating system receive an unadjusted free-ridership score.

We believe that estimating program influence on contractor stocking and sales practices and then adjusting FR scores using the approach proposed above is appropriate, given the nature of the program and our experience conducting this type of research.

Our proposed approach allows us to reasonably bind the degree to which contractor interviews can impact the overall FR score. It also allows us to understand and quantify program influence on the sales and stocking practices among participating contractors and adjust the final FR estimate accordingly.

Independent Free-Ridership Estimate through Contractor Research

To supplement the approach described above, we included questions about the program's influence on contractor sales and installations in the participating contractor survey. We intended to calculate an alternative FR rate, using the following survey question:

> *I6. If the Gas Heating program incentives, marketing, and support had not existed, what percent of the program rebated <MEASURE> do you think you would still have installed?*

To provide additional context, this question was followed with an open-ended question:

> *I7. Why do you say that? [OPEN END]*

Results from this analysis were intended to provide an alternative perspective on program influence on the market for high-efficiency heating equipment. These results were not intended to be introduced into the quantitative derivation of the NTGR results described above.

After review of contractor responses to these two questions, we decided not to present the results of this analysis. Open-ended responses such as "customers needed new furnaces" indicated that many respondents were not able to answer the question accurately and did not distinguish between the installation of any new measure and the installation of a measure with the same efficiency. We therefore believe that these responses do not provide an accurate picture of program influence on the market for high-efficiency equipment.

Additional Free-Ridership Results

Measure-Level FR Results

In addition to estimating FR at the program level, by PA, we also developed measure-level FR estimates. For the purposes of the measure-level FR analysis, we grouped furnaces with and without ECM into one "Furnaces" category, and we grouped water boilers and steam boilers into one "Boilers" category.

Sampling for the measure-level analysis was designed to achieve 10% precision at 90% confidence at the PA group level. In the following tables, we present measure-level FR results (including adjustments based on contractor research) at four different levels: 1) statewide, 2) by upstate and downstate,[80] 3) by PA group,[81] and 4) by PA. Each table also shows the number of completed interviews associated with each free-ridership value (n)[82] as well as the precision level (at 90% confidence).

Users of the measure-level FR estimates should note the following:

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[80] The nine PAs are mapped into upstate and downstate regions as follows: Upstate: National Fuel, NiMo, Central Hudson, Corning, and Enbridge; and Downstate: KEDLI, KEDNY, Con Edison, and O&R.

[81] Based on the approved Overview of Primary Data Collection Efforts and Net Impact Evaluation Approach, the three PA groups are defined as follows: Group 1: National Fuel, Group 2: KEDLI, KEDNY, and Con Edison, and Group 3: NiMo, Central Hudson, Corning Gas, Enbridge St. Lawrence, and O&R

[82] Note that the number of completed interviews refers to the participant survey part of the FR estimate. We attempted a census of all contractors in our sample frame.

1. Estimates developed at an aggregate level (i.e., statewide, upstate/downstate, or PA group) are not always representative of every individual PA included in that aggregation. Because of the significant range in the number of rebated measures across the PAs, PAs do not contribute equally to the aggregate measure-level results (which are weighted by each PAs measure savings).

2. We used measure-level FR results at the PA level to develop the program-level free-ridership numbers. However, for most PAs, measure-level FR estimates are generally based on very few responses. These PA/measure-level results therefore may not be representative of the PA's program at the measure level and should not be used for program planning or measure-specific analyses.

Table A-6. Summary of Measure-Level Free-Ridership – Statewide and Upstate/Downstate

	Statewide			Upstate			Downstate		
Measure	FR	n	Prec.	FR	n	Prec.	FR	n	Prec.
Furnaces	38.9%	684	5%	39.2%	561	6%	35.3%	123	*
Boilers	36.2%	530	4%	37.2%	232	4%	35.5%	298	5%
Indirect Water Heater	37.9%	245	4%	39.2%	99	*	37.4%	146	5%
Thermostats	40.4%	588	6%	40.0%	458	6%	42.9%	130	9%
Boiler Reset Control	37.1%	96	*	32.2%	44	*	38.4%	52	*
Overall	38.5%	2,143	4%	39.1%	1,394	5%	36.2%	749	3%

* Census attempt; no sampling error

Table A-7. Summary of Measure-Level Free-Ridership – by PA Group

	Group 1			Group 2			Group 3		
Measure	FR	n	Prec.	FR	n	Prec.	FR	n	Prec.
Furnaces	36.8%	258	8%	32.3%	106	*	42.2%	320	8%
Boilers	35.4%	92	*	33.9%	285	6%	40.9%	153	6%
Indirect Water Heaters	38.8%	25	*	34.5%	137	5%	44.1%	83	*
Thermostats	38.2%	212	9%	39.9%	116	10%	43.7%	260	8%
Boiler Reset Controls	--	--	--	40.6%	45	*	34.7%	51	*
Overall	36.9%	587	7%	34.0%	689	3%	42.1%	867	6%

* Census attempt; no sampling error
-- Measure not present in group, no FR estimated

Table A-8. Summary of Program-Level Free-Ridership – Upstate PAs

Measure	National Fuel		NiMo		Central Hudson		Corning		Enbridge	
	FR	n	FR	n	FR	n	FR	n	FR	n
Furnaces	36.8%	258	41.6%	205	32.5%	26	54.4%	28	52.1%	44
Boilers	35.4%	92	40.1%	78	29.8%	44	32.6%	6	43.4%	12
Indirect Water Heater	38.8%	25	39.8%	37	36.2%	26	46.4%	4	39.5%	7
Thermostats	38.2%	212	42.3%	192	36.0%	19	67.5%	18	38.7%	17
Boiler Reset Control	--	--	27.1%	11	29.4%	22	56.4%	3	37.7%	8
Program Overall	36.9%	587	41.5%	523	31.8%	137	50.4%	59	47.8%	88
Precision @ 90% Confidence	7%		7%		7%		*		*	

* Census attempt; no sampling error
-- Measure not present in group, no FR estimated

Table A-9. Summary of Program-Level Free-Ridership – Downstate PAs

Measure	KEDLI		KEDNY		Con Edison		O&R	
	FR	n	FR	n	FR	n	FR	n
Furnaces	24.4%	16	39.5%	46	35.1%	44	53.0%	17
Boilers	29.0%	110	37.0%	109	35.9%	66	51.4%	13
Indirect Water Heater	32.9%	81	35.7%	27	38.4%	29	55.8%	9
Thermostats	39.2%	47	37.4%	44	49.4%	25	63.6%	14
Boiler Reset Control	31.9%	39	16.6%	1	50.0%	5	36.1%	7
Program Overall	29.6%	293	37.5%	227	36.5%	169	51.8%	60
Precision @ 90% Confidence	4%		7%		8%		*	

* Census attempt; no sampling error

Contextualizing Participant Free-Ridership Results

As part of our participant research, we asked participants a limited number of questions intended to contextualize the participant self-reported free-ridership results. Below, we provide a descriptive summary of the responses to these questions followed by table with the quantitative results for each PA and statewide.

<Q.2a plus Q.1=1> Did your contractor talk to you about <PROGRAM ADMINISTRATOR>'s gas heating rebate program?

- Most participants (78%) reported that their contractor spoke to them about the Programs. Enbridge and O&R had much lower reported rates of contractor involvement, with only 66% and 58% of participants, respectively, reporting that their contractor spoke to them about the Programs.

<Q.2b plus Q.1=2,3> Did you receive any marketing or informative materials or see any advertising from <PROGRAM ADMINISTRATOR> about the benefits of energy efficient heating equipment or available rebates?

- Only 25% of O&R participants reported receiving any marketing materials or encountering any program advertising, compared to a statewide average of 44%. These results, to some degree, might explain O&R's relatively high free-ridership scores, as participants might not have learned about rebate availability until after they had decided to install high efficiency heating equipment.

<Q.3> Did you receive a tax credit or rebate from the government for the heating equipment that you installed?

- A substantial number of participants in the Programs (37%) recalled receiving government tax credits or rebates for the high efficiency heating equipment they installed. Over half of upstate participants (51%) report receiving these, with just over one third (35%) of downstate participants reporting the same. Upstate free-ridership is slightly higher than downstate free-ridership, which could be in part explained by a larger percentage of respondents already being financially motivated to install high efficiency equipment by these rebates.

<Q.FR0c> At the time that you replaced your old heating system with a <MEAS> through the <PROGRAM ADMINISTRATOR> program, was your old heating system still working?

- It does appear that the Programs motivate early replacement, as overall 78% of participants report that at the time they replaced their old heating system, their current system was still working. These rates appear high both upstate and downstate and across PAs.

<Q.FR0d> Which of the following best describes the condition of your old heating system? [ASKED OF THOSE WITH SYSTEM STILL WORKING]

1. *The old system was working with no need of repair*
2. *The old system was working with need of minor repair*
3. *The old system was working with need of major repair*

- Overall, 52% of participants who replaced a working heating system said that it was working with no need of repair, indicating early replacement of a completely functional heating system. One quarter (24%) reported that their system was working with need of minor repair, and one quarter (24%) reported their system was working and in need of major repair. No particularly strong patterns are noted – downstate customers appear somewhat more likely to have replaced a system in no need of repair, and upstate customers appear somewhat more likely to have replaced systems in need of major repair, but these differences are not major.

<Q.FR2a> Were you already planning to install a new <MEAS> when you learned that you could receive a rebate from <PROGRAM ADMINISTRATOR>?

- Statewide, participants report that they were planning to install two-thirds (64%) of program-rebated measures before learning they could receive a rebate from their PA. This appears relatively consistent across regions and groups. Participants served by some smaller PAs (Enbridge, Central Hudson, and Corning) report planning to install over 70% of measures rebated through the Programs, while participants served by O&R report planning to install only 57% of measures rebated through the Programs.

<Q.FR2b Were you already planning to install a HIGH EFFICIENCY <MEAS> when you learned that you could receive a rebate from <PROGRAM ADMINISTRATOR>? [Not asked for IWH or controls – these answers were filled in by their implied response to Q.FR2a]

- Statewide, participants report that they were planning to install more than half (64%) of the high efficiency measures installed through the Programs before learning they could receive a rebate from their PA. In this case, there is some variation across PAs and regions – participants served by upstate PAs report already planning on high efficiency measure installations at a higher rate (67%) than downstate PAs (60%). NiMo has a particularly high rate of participants already planning to install high efficiency measures (70%), while Con Edison participants report only planning to install just over half (55%) of the high efficiency measures actually installed before they learned they could receive a rebate.

Table A-10 below summarizes responses to the above questions, by PA. To facilitate synthesis of the presented frequencies, we highlight in red and italics values that indicate a higher than statewide likelihood of free-ridership, while we highlight in green and bold values that indicate a lower than statewide likelihood of free-ridership.[83] For example, everything else being equal, customers who received a tax credit for the installed equipment are more likely than others to be a free-rider. Therefore, a high percentage of customers who recalled receiving a tax credit would suggest a higher free-ridership score. Conversely, customers who replace systems that are no longer working might be more likely to be free-riders than those who retrofit a working system. Therefore, a high percentage of customers who replace a working system would suggest a lower free-ridership score.

Review of Table A-10 shows some (but not perfect) correlation between the PAs unadjusted estimate of participant FR and responses to the contextual free-ridership questions. For example, KEDLI has the lowest unadjusted participant FR score and ranks favorably on all but one of the contextual questions, relative to the statewide average. In contrast, Corning and Enbridge have the two highest unadjusted FR scores and rank unfavorably, relative to the statewide average, on all but the two questions about the condition of their prior heating system.

[83] It should be noted that the shading does not imply a statistically significant difference. It merely indicates values that are above or below the statewide value.

Table A-10. Summary of Contextual Free-Ridership Questions by PA

PA	Unadjusted Participant FR%	Contractor Talked to Participant About Program	Recalled Marketing Materials	Recalled Received Tax Credit	Heating System Is Working	Heating System in Need of No Repair*	Planned to Install Before Learned About Rebate	Planned to Install HE Before Learned About Rebate
Central Hudson	43%	82%	54%	*52%*	*74%*	65%	*71%*	*69%*
Con Edison	47%	*74%*	46%	37%	82%	51%	63%	55%
Corning	*66%*	*69%*	*37%*	*40%*	91%	50%	*70%*	*69%*
Enbridge	*61%*	*66%*	*42%*	*40%*	87%	52%	*77%*	*74%*
National Fuel	*55%*	82%	48%	*43%*	*74%*	*41%*	61%	61%
KEDLI	36%	78%	51%	24%	95%	64%	61%	57%
KEDNY	46%	*77%*	46%	27%	*74%*	52%	64%	*64%*
NiMo	*52%*	84%	*39%*	*42%*	*73%*	*42%*	*68%*	*70%*
O&R	*58%*	*58%*	*25%*	*43%*	*67%*	75%	57%	60%
Statewide	52%	78%	44%	37%	78%	52%	64%	64%

* Of systems that are working.

Detailed Participant Spillover Methodology

Spillover represents additional savings (expressed as a percent of total program savings) that were achieved without program rebates, but would not have happened in the absence of the program.

Our spillover analysis included measures that could reasonably be expected to be influenced by program participation and are more likely to have been implemented without program support. Participant spillover was measured for the following equipment:

- Insulation
- Windows
- Faucet aerators
- Low-flow shower heads
- *ENERGY STAR* refrigerators
- *ENERGY STAR* washing machines
- Non-indirect water heaters

In addition, we included questions asking participants to list any other energy-efficient equipment installations made outside of the program that were influenced by their participation.

Participants were asked if they had any of the above-listed equipment installed. Those who did were asked if the PA's program was of any influence and, if so, the degree of influence. Respondents were also asked to explain how the program influenced their decision to make specific additional energy efficiency improvements. A careful screening of these responses allowed us to screen-out respondents whose additional energy efficiency actions were not a result of spillover.

Questions:

SO1. Did you insulate your home without receiving a rebate?

[IF YES]

SO2. Why did you decide to add insulation? [OPEN END]

SO3. Did your experience with the <PROGRAM ADMINISTRATOR> high efficiency gas heating program encourage you IN ANY WAY to insulate your home? [OPEN END]

SO4. Using a scale of 1 to 7, where 1 is no influence and 7 is a great deal of influence, how much influence did your experience with the <PROGRAM ADMINISTRATOR> high efficiency gas heating program have on your decision to insulate your home?

SO5. Can you explain how your experience with the <PROGRAM ADMINISTRATOR> high efficiency gas heating program influenced your decision to insulate your home?

The evaluation team calculated spillover for participants who met three criteria:

1. The customer must have installed an energy-efficient measure without having received a rebate.

2. The customer must have indicated a high level of program influence on the choice to install the measures (a rating of 6 or 7 on a scale of 1 to 7, where 1 means "no influence" and 7 means "a great deal of influence").

3. There must be evidence within the response to an open-ended survey question that supports the influence of the program.

Of the 1,363 participants who completed the survey, 18 met the three conditions above and were considered for participant spillover. For 15 of these 18 participants, we estimated spillover savings.[84] These participants installed the following measures outside the program: attic insulation, basement insulation, windows, direct natural gas water heater, indirect natural gas water heater, low-flow showerheads, and programmable thermostats.

Table A-11 below shows the equations to calculate the per-unit savings for spillover measures, as well as the source of the savings algorithm or assumption. Where possible, we based the savings calculation on the NYTM or used ex post per-unit savings, as estimated in this evaluation.

Table A-11. Algorithms Used to Calculate per-Unit Spillover Savings

Measure	Units	Therm Savings Equation	Source
Attic Insulation	Per 1,000 square foot	SF * (Δtherms/kSF) * (AFUEbase/AFUEpart)* (ηbase/ηpart)	NYTM
Basement Insulation	Per 1,000 square foot	SF * (Δtherms/kSF) * (AFUEbase/AFUEpart)* (ηbase/ηpart)	NYTM
New Windows	Per 100 square feet	SF * (Δtherms/100SF) * (AFUEbase/AFUEpart)* (ηbase/ηpart)	NYTM
Direct Gas Water Heater (Storage and Tankless)	Per Water Heater	units * ((GPD * 365 * 8.33 * ΔTw)/100,000)*((1/Efbase)-(1/Efee))	NYTM
Indirect Gas Water Heater	Per Water Heater	PA-specific average per-unit ex post value from evaluation	2009 – 2011 Evaluation
Low-Flow Showerhead	Per LF Showerhead	((GPMbase - GPMee) * throttle factor * mins/shower * #showers/day/person * 365 days/yr)* Tshower - Tmains) * (8.3)/(100,000)/EF	NYTM
Programmable Thermostats	Per Programmable Thermostat	Average per-unit ex post value from evaluation	2009 - 2011 Evaluation

Table A-12 below presents more detail on spillover measure assumptions and the per-unit savings we estimated.

[84] Three participants indicated installing measures that were either electric savings only (i.e., a PV system) or insufficient information was provided and the evaluation team was unable to determine whether it was gas or electric equipment that was installed.

Table A-12. Spillover Measure Assumptions and Per-Unit Savings

Spillover Measure	Savings (therms/unit)	Quantity	Source	Assumptions
Attic Insulation (R-30 to R-38)	7.97 / 1000 ft²	2.04	- NYTM - Zillow.com	One National Fuel participant installed attic insulation. Attic footprint based on square footage and number of stories (single story) found at Zillow.com. Survey indicated 30" of insulation in place prior to the addition of attic insulation. It was assumed that the participant meant R-30 was in place. Assumed R-38 (code) for post attic insulation. Calculation based on location of home; used representative city Buffalo for home located in West Seneca, NY.
Attic Insulation (R-11 to R-38)	61.83 / 1000 ft²	1.57	- NYTM - Zillow.com - ASHRAE Fundamentals 2013 Section 26.8 Table 1	One Corning participant installed attic insulation. Attic footprint based on square footage and number of stories (single story) found at Zillow.com. Survey indicated 4" of insulation in place for pre-existing attic insulation (R-11 calculated using ASHRAE R-value/inch for batt insulation. Survey indicated installing 12" of batting (R-38 calculated using ASHRAE R-value/inch for batt insulation). Calculation based on location of home; used representative city Binghamton for home located in Corning, NY.
Basement Wall Insulation (R-11 to R-13)	7.45 / 1000 ft²	1.45	- NYTM - Trulia.com - Zillow.com	One National Fuel participant installed basement insulation. The square footage of the home was determined from Zillow.com. Basement wall area calculated using (√CFA)*#walls*wallheight = 1,446 sf. The pre and post R-values are unknown; therefore assumed R-11 to R-13 (code). Assumed some insulation in place based on location of home (cold climate). Calculation based on location of home; used representative city Buffalo for home located in West Seneca, NY.
New Windows	18.72 / 100 ft²	3 (windows)	- NYTM	Two National Fuel participants installed a total of three new windows. Assumed new window type is double pane and the estimated size of the window is 15ft² (3 x 5). Calculation based on location of home; used representative city Buffalo for home located in Tonawanda, NY and Ransomville, NY.
New Windows	8.44 / 100 ft²	13 (windows)	- NYTM	One KEDLI participant installed 13 new windows. Assumed new window type is double pane and the estimated size of each window is 15ft² (3 x 5). Calculation based on location of home; used representative city NYC for home located in Westbury, NY.
Low Flow Showerhead	8.29 / showerhead	2	- NYTM - IL TRM v.3.0	One KEDLI participant installed two low-flow showerheads. Assumed 0.6 showers/day/person per the IL TRM. Assumed 2.5 gpm low flow showerhead installed (Δgpm agrees with IL TRM and IN TRM). All other assumptions from the NYTM.
Direct Gas Storage Water Heater	31.88 / water heater	2	- NYTM	One National Fuel and one Central Hudson participant installed a gas storage water heater. Assumed replaced gas storage water heater (40 gallon) with baseline efficiency 0.54. Estimated efficiency of installed water heater is 0.65. Calculation based on number of

Spillover Measure	Savings (therms/unit)	Quantity	Source	Assumptions
				occupants in the home to determine gallons of water used per day. Gallons per day for two occupants is 46 GPD.
Direct Gas Storage Water Heater	77.60 / water heater	1	- NYTM	One KEDNY participant installed a gas storage water heater. Assumed replaced gas storage water heater (40 gallon) with baseline efficiency of 0.54. Estimated efficiency of installed water heater 0.65. Calculation based on number of occupants in the home to determine gallons of water used per day. Gallons per day for six occupants is 111 GPD.
Direct Tankless Water Heater	42.42 / water heater	1	- NYTM	One Central Hudson participant installed a tankless water heater. Assumed replaced gas storage water heater (40 gallon) with baseline efficiency of 0.54. Estimated efficiency of installed tankless water heater is 0.82. Calculation based on number of occupants in the home to determine gallons of water used per day. Gallons per day for one occupant is 29 GPD.
Direct Tankless Water Heater	65.80 / water heater	1	- NYTM	One NiMo participant installed a tankless water heater. Assumed replaced gas storage water heater (40 gallon) with baseline efficiency of 0.54. Estimated efficiency of installed tankless water heater is 0.82. Calculation based on number of occupants in the home to determine gallons of water used per day. Gallons per day for two occupants is 46 GPD.
Indirect Gas Water Heater	Per water heater: KEDLI 76 NiMo 77 National Fuel 68	3	- 2009 - 2011 Ex Post Evaluation	Three participants (KEDLI, NiMo, National Fuel) installed indirect water heaters. The average ex-post per unit value from the 2009-2011 HEHE evaluation was applied for this measure.
Programmable Thermostat	20 / PT	5	- 2009 – 2011 Ex Post Evaluation	One Con Edison participant installed five programmable thermostats. The average ex post per-unit value from the 2009-2011 HEHE program evaluation was applied for this measure.

For each PA, participant spillover was calculated by dividing the estimated spillover savings of survey respondents by the respondents' ex post gross program impacts:

$$\text{Participant Spillover Rate}_{PA} = \frac{\text{Net Participant Spillover}_{PA}}{\text{Ex Post Gross Program Impacts}_{PA}}$$

Detailed Distributor Findings

Table A-13 summarizes responses from interviews with distributors, by question.

Table A-13. Summary of Distributor Interview Findings by Question

Question	Summary of Responses
Q1: Number of employees	• Between 6 and 135 employees.
Q2a: Area of service in NY	• Interviewed distributors cover the entire state of NY. Two service the entire state; the other five focus on specific regions within the state (Central NY, Southern Tier, mostly Upstate, Southwestern NY, and Upstate NY).
Q2b: Other states served	• Three only sell equipment in NY; the other four also sell equipment in PA, CT, and/or NJ.
Q3: Types of residential gas heating equipment sold	• All interviewed distributors have sold all types of major residential gas heating equipment (furnaces, water boilers, steam boilers, and indirect water heaters) in the past five years.
Q4: Familiarity with the gas heating rebate programs offered to residential customers in New York	• Three interviewed distributors are very familiar with the programs and three distributors are somewhat familiar with the programs. Only one respondent was not very familiar with the programs.
Q5a: Impact of programs on overall sales	• Most distributors (5 out of 7) reported that the programs had a large impact on their sales. o One distributor said the programs increased sales but also shifted sales towards gas equipment. o Another distributor estimated that his sales increased by 50% due to the rebates. • Two distributors claimed the programs had little to no effect on their sales.
Q5b: Impact of programs on efficiency levels of the units sold	• The majority of distributors (5 out of 7) reported that the programs increased the efficiency of units sold. • Two distributors found that the programs had little impact on the efficiency levels of the equipment sold. o One of the distributors said efficiency levels did not increase because consumers were already buying energy efficient equipment.
Q6: Approximate number of units sold per year (2009 to 2011), for each type of gas heating equipment	• Respondents could not provide estimates.
Q7a-c: Sales by efficiency levels (2009 to 2011), for furnaces, water boilers, and steam boilers	• Respondents could not provide estimates.
Q8: Approximate number of units that would have been sold per year between	• Respondents could not provide estimates.

Question	Summary of Responses
2009 and 2011 if rebate programs had not been available	
Q9a-c: Estimate of sales by efficiency levels (2009 to 2011) without rebates, furnaces, water boilers, and steam boilers	• Respondents could not provide estimates.
Q10: Influence of rebate programs on efficiency level of heating equipment offered by manufacturers	• All interviewed distributors thought that manufacturers are definitely offering more high efficiency equipment as a result of the programs.
Q11: Further comments about the impact of rebate programs on the markets for high efficiency heating equipment in NY	• Comments by individual respondents: o The rebates have helped to educate people about high efficiency heating equipment. o Dollar amounts of rebates are decreasing – this is bad news because all of these programs, both federal and local, are great for the economy and sales. • A few distributors noted that as rebates decrease, people are going to buy lower efficiency heating equipment.

Appendix B. Detailed Data Collection Methods

This appendix provides additional information on the primary data collection efforts for this evaluation. It includes information on sample design and survey dispositions for the three survey efforts conducted in support of the net impact analysis: the participating customer survey, the participating contractor survey, and the in-depth interviews with distributors.

Participant Survey Sample Design

The sample design process began with a count of participants by measure category and PA group. While the net impact evaluation covers program activity between 2009 and 2011, we expected issues remembering the decision-making process that led to the selection and installation of the high-efficiency equipment among earlier participants (2009 and 2010 especially). To minimize these issues, we chose a sample frame including participants from the last year of the evaluation period (2011) supplemented with 2012 participants to enable free-ridership and spillover estimation on as detailed level as possible (by measure category and PA). We carefully reviewed changes in program design between 2009 and 2012 and found them to be minimal, especially between 2011 and 2012, which allowed us to include participants from 2012 in the sample frame. Including participants from the most recent years has another benefit – if the NTGR is applied prospectively, gathering data from the most recent pool of participants is likely to best reflect the current state of the market in terms of end-user decision-making.

The RFP called for free-ridership and spillover estimates by measure category and PA, where possible and feasible. After review of the participant databases, we determined that it was not feasible to provide measure-level NTGR estimates at our target level of confidence and precision for each individual PA. Instead, we provide program-level NTGR estimates for each PA, as well as measure-level NTGR estimates for three groups of PAs, at 90% confidence and 10% precision.

We designed the participant survey to ask each participant about up to, but no more than two measures installed through the Programs in order to minimize respondent burden and fatigue. The overwhelming majority of participants in our sample (95%) installed only one or two measures through the Programs. For those who installed three or more measures, we prioritized the measures the participant would be asked about by the relative incidence of the measures within the group – in other words, we asked about relatively less common measures at the expense of more common measures.

In order to minimize participant confusion, we also combined furnaces and furnaces with ECM for the free-ridership questions, while retaining the ability to separate them out after the fact if needed. We eventually chose to combine furnace types for analysis.

Finally, due to the extremely low measure incidence and low contribution to savings of the Programs, we chose to omit duct and air sealing from our free-ridership questions. These measures received the program-level NTGR in the final analysis.

We developed preliminary estimates of necessary completed interviews needed to achieve 10% precision at 90% confidence, with an assumption of a coefficient of variation (CV) of 0.7 and application of a finite population correction factor.[85] For each measure category and PA combination,

[85] The CV of 0.7 came from previous evaluations of HVAC programs. This was not a perfectly accurate CV for this particular study, but we were unable to know the CV for this study until data was collected. In some cases, preliminary CVs were different

we calculated the number of interviews was feasible to expect given the size of the sample frame for each measure, using an assumed completion rate of 10%.[86] We then compared these results (the "desired" sample size) to the reasonably expected number of completed interviews (the "possible" sample size).

Our preliminary review suggested that in many cases, it was possible to achieve our target level of confidence and precision at the measure level for each PA group. For these cases, we set preliminary quotas of respondents to be contacted, monitored the CV of these groups during fielding, and modified quotas as necessary to meet or exceed our target level of confidence and precision. For those cases in which precision was not met, we conducted a census attempt, i.e., we attempted to contact every program participant in the given group who installed a measure of that type. We conducted enough interviews to meet measure-level precision targets for each PA group as well as program–level targets for each PA.[87]

Table B-1 presents our final sample frame for the participant survey, including all drops made because of missing participant contact information.

Table B-1. Final Sample Frame, by PA and Measure Type

	Participants in Sample Frame by Measure Type						
Utility	Furnace	Water Boiler	Steam Boiler	Indirect Water Heater	Boiler Reset Control	Programmable Thermostat	Total[A]
Central Hudson	256	309	4	147	120	225	592
Con Edison	324	427	424	205	84	215	1,192
Corning	154	27	5	13	8	123	186
Enbridge	176	55	0	17	25	66	231
National Fuel	8,405	534	27	158	0	6,492	9,355
KEDLI	175	1,544	399	898	223	973	2,193
KEDNY	548	475	2,044	199	19	800	3,174
NiMo	7,325	832	86	201	35	5,902	8,403
O&R	137	120	16	89	93	183	330
Total	17,500	4,323	3,005	1,927	607	14,979	25,656

[A]Customers with multiple measure installations are listed in each applicable measure category. Therefore, the total across measure categories will be greater than the number of unique participants for each PA.

than our assumptions for particular measure/PA combinations, requiring correction to the desired number of interviews during fielding.

[86] The completion rate of 10% came from a previous evaluation of HVAC programs and is expected for this type of survey effort. This completion rate is not the final response rate. The 10% planning assumption includes participants who did not complete a survey because they were not eligible or possible to contact (e.g., do not recall participation or had moved), those who were unreachable (e.g., did not answer their phone after repeated attempts), and those who refused to participate. We tracked actual call dispositions using the American Association of Public Opinion Research (AAPOR) Standard Definitions and present AAPOR response rates in the section immediately following.

[87] Note that for some PAs (Corning, Enbridge, and O&R), we attempted to contact all participants (census attempt). For these PAs, sampling error, and therefore precision around our NTGR estimates, does not apply.

Participant Survey Dispositions

Table B-2 presents the overall final dispositions for the participant survey. The response rate was 12% (computed as the number of completed interviews divided by the number of eligible respondents). The cooperation rate was 29% (computed as the number of completed interviews divided by the total number of eligible sample units actually contacted).

Table B-2. Overall Participant Survey Dispositions

Disposition	Participants
Completed Interviews (I)	1,363
Partial	18
Eligible Non-Interviews	6,737
Refusals (R)	3,100
Mid-interview terminate (R)	169
Answering machine (NC)	2,344
Respondent never available (NC)	1,048
Language problem	76
Not Eligible (e)	1,564
Fax/data line	82
Duplicate number	17
Non-working	822
Wrong number	273
No eligible respondent	115
Quota filled	12
Business or other institutions	243
Unknown Eligibility Non-Interview (U)	3,290
Not attempted or worked	1,764
Always busy	146
No answer	1,324
Call blocking	56
Total Contacts in Sample	12,972
Response Rate	12%
Cooperation Rate	29%

Source: Opinion Dynamics Telephone Interviewing Services

We calculated the response rate using the standards and formulas set forth by the American Association for Public Opinion Research (AAPOR).[88] For various reasons, we were unable to determine the eligibility of all sample units through the survey process, and chose to use AAPOR Response Rate 3 (RR3). RR3 includes an estimate of eligibility for these unknown sample units. The formulas used to calculate RR3 are presented below. The definitions of the letters used in the formulas are displayed in the table above.

$$E = (I + R + NC) / (I + R + NC + e)$$

Where "E" is the percentage of respondents with whom we have made contact that is eligible.

[88] *Standard Definitions: Final Dispositions of Case Codes and Outcome Rates for Surveys*, AAPOR, 2009. http://www.aapor.org/Standard_Definitions/1818.htm.

RR3 = I / ((I + R + NC) + (E*U))

The cooperation rate is the number of completed interviews divided by the total number of eligible sample units actually contacted. In essence, the cooperation rate gives the percentage of participants who completed an interview out of all of the participants with whom we actually spoke. We used AAPOR Cooperation Rate 1 (COOP1), the formula for which is shown below. The definitions of the letters used in the formulas are displayed in the table above.

COOP1 = I / (I + R)

Table B-3 presents participant dispositions by PA.

Table B-3. Participant Survey Dispositions by PA

Disposition	Central Hudson	Con Edison	Corning	Enbridge	National Fuel	KEDLI	KEDNY	NiMo	O&R
Completed Interviews (I)	85	116	35	62	389	160	163	313	40
Partial	1	1	0	0	5	4	1	6	0
Eligible Non-Interviews	345	617	94	112	1,681	876	1,166	1,637	209
Refusals (R)	180	289	44	60	805	270	562	777	113
Mid-interview terminate (R)	11	9	3	2	41	33	30	35	5
Answering machine (NC)	98	196	29	35	586	405	338	604	53
Respondent never available (NC)	52	109	17	15	243	162	201	213	36
Language problem	4	14	1	0	6	6	35	8	2
Not Eligible (e)	92	147	25	25	396	157	295	383	44
Fax/data line	2	13	0	1	17	7	26	14	2
Duplicate number	0	0	0	0	4	2	6	4	1
Non-working	56	87	15	13	176	96	149	218	12
Wrong number	8	20	2	4	86	21	60	63	9
No eligible respondent	9	12	2	1	24	11	21	29	6
Quota filled	0	0	4	0	5	0	1	2	0
Business or other institutions	17	15	2	6	84	20	32	63	14
Unknown Eligibility Non-Interview (U)	68	168	32	32	999	932	313	709	37
Not attempted or worked	0	0	0	0	680	736	11	337	0
Always busy	2	12	2	6	17	23	40	36	8
No answer	62	152	25	24	297	165	254	317	28
Call blocking	4	4	5	2	5	8	8	19	1
Total Contacts in Sample	591	1,049	186	231	3,470	2,192	1,938	3,048	330
Response Rate	17%	13%	22%	30%	13%	8%	10%	12%	14%
Cooperation Rate	31%	28%	43%	50%	31%	34%	22%	28%	25%

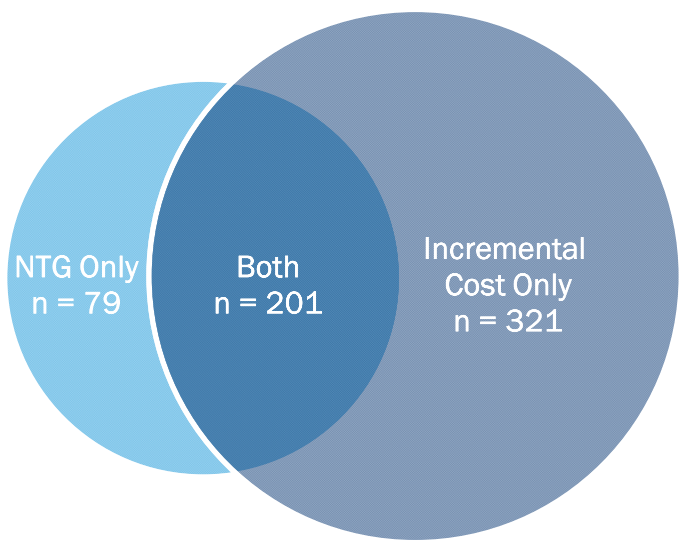
Contractor Survey Sample Design

Similarly to the participant survey, the contractor survey sample design process began with a count of contractors by PA. The contractor survey served multiple purposes – both for attribution, where we used contractor survey responses to adjust participant free-ridership scores, and for incremental cost. We originally selected only those contractors who completed five or more projects through the Programs to include in our sample frame – those contractors accounted for the vast majority of program savings, and given limited evaluation resources, we initially planned to exclude contractors with only minor involvement in the Programs from our sample and ask incremental cost and attribution questions of all respondents. Project-level data for participating contractors was not available for Enbridge, so we did not include Enbridge in our sample design for the contractor survey. Each contractor was assigned to a PA for purposes of analysis and reporting; if a contractor completed projects across multiple PA territories, we generally assigned that contractor to the PA for which they had completed the most projects. In some cases, a contractor was reassigned to another PA for which they completed fewer projects in order to have a sufficient number of completes for analysis.

After discussion and DPS recommendations, we modified our sample design to use a "snowball" approach, where we only asked attribution questions to those contractors in our sample whom participants had earlier identified as being influential in their choice to install high-efficiency heating equipment. In order to increase the small number of contractors identified, we added contractors to our sample whom participants had identified as being influential in their choice to install high-efficiency heating equipment but who had completed less than five projects through the Programs. However, we only asked attribution questions to these contractors; we did not include them in our incremental cost sample.

These modifications to our sample design produced a segmented sample, visualized with final counts in Figure B-1, where some contractors received only attribution questions, some contractors received only incremental cost questions, and some contractors received both.

Figure B-1. Number of Contractor Receiving Survey Modules



It is important to note that we experienced significant losses in our sample due to missing contact information. Our initial sample frame consisted of 1,079 contractor contacts, but even after substantial effort and electronic lookup of contractor information, we were unable to include 478 contractors in our sample for which we did not have phone numbers or who were on our do not call list. We called and attempted to complete interviews with all 601 remaining contractors (census attempt). To increase participation in the survey, we offered contractors an incentive of $50 for completion of the interview.

Contractor Survey Dispositions

Table B-4 presents the final dispositions for the contractor survey. The response rate was 21% (computed as the number of completed interviews divided by the number of eligible respondents). The cooperation rate was 39% (computed as the number of completed interviews divided by the total number of eligible sample units actually contacted; see discussion above for formulas).

Table B-4. Contractor Survey Dispositions

Disposition	Contractors
Completed Interviews (I)	115
Eligible Non-Interviews	363
Refusals (R)	168
Mid-interview terminate (R)	9
Answering machine (NC)	74
Respondent never available (NC)	112
Not Eligible (e)	59
Fax/data line	2
Duplicate number	1
Non-working	32
Wrong number	18
Unknown Eligibility Non-Interview (U)	64
Always busy	3
No answer	60
Call blocking	1
Total Contacts in Sample	601
Response Rate	21%
Cooperation Rate	39%

Source: Opinion Dynamics Telephone Interviewing Services

Distributor Survey Sample Design and Dispositions

The sample frame for distributor interviews was developed based on two sources: 1) a list of New York distributors provided by some of the PAs and 2) recommendations from participating contractors interviewed for this evaluation. Overall, the sample frame included 68 unique distributors in New York.

We called and attempted to complete interviews with all of these distributors (census attempt). Of the 68 distributors, 44 (65%) were reached but refused to answer our questions; another 14 could not be reached for various reasons. Table B-5 shows the final disposition of the 68 distributors we attempted to contact. Distributors coded as “Answering Machine,” “Callback,” or “No Answer” were called between three and five times each.

Table B-5. Disposition of Distributor Interviews

Disposition	Number of Distributors
Completed	7
Refused	44
Answering Machine	5
No Answer	2
Callback	3
Wrong Number[a]	7
Total	68

[a] Attempts to find correct numbers for these distributors were unsuccessful.

Appendix C. Data Collection Instruments

Participant Survey Instrument

Sample Variables
<PARTICIPANT NAME>
<PROGRAM ADMINISTRATOR>
<ADDRESS>

<ECM>
<FURN>
<STM>
<WTR>
<IWH>
<TSTAT>
<RESET>
<SEAL>
<ECM_INCENTIVE>
<FURN_INCENTIVE>
<STM_INCENTIVE>
<WTR_INCENTIVE>
<IWH_INCENTIVE>
<TSTAT_INCENTIVE>
<RESET_INCENTIVE>
<SEAL_INCENTIVE>

Introduction

Hi, my name is ____ and I'm calling from Opinion Dynamics, an independent research company, on behalf of your gas provider, <PROGRAM ADMINISTRATOR>. We're speaking with <PROGRAM ADMINISTRATOR> customers who have participated in their rebate program for gas heating equipment.

May I please speak with <PARTICIPANT NAME> or the person most knowledgeable about your participation in the Central Hudson program?

I would like to ask you some questions about your experience with the <PROGRAM ADMINISTRATOR> high efficiency gas heating rebate program, as this information will help <PROGRAM ADMINISTRATOR> understand how the program may be improved. The questions that I have will only take about 15 minutes and your responses will be kept strictly confidential.

For quality control purposes this call may be monitored or recorded.

C1. Are you currently talking to me on a regular landline phone or a cell phone?
1. Regular landline phone
2. Cell Phone
8. (Don't know)
9. (Refused)

[ASK IF C1 = 2; ELSE GO TO SURVEY START]

C2. Are you currently in a place where you can talk safely and answer my questions?

1. Yes
2. No [SCHEDULE CALL BACK]
8. (Don't know) [SCHEDULE CALL BACK]
9. (Refused) [SCHEDULE CALL BACK]

Address Verification

EV1. Our records show that you received a rebate from <PROGRAM ADMINISTRATOR> for making energy efficient upgrades at <ADDRESS> in <INSTALL YEAR>. Is this correct?

1. Yes
2. No, did not
8. (Don't know)
9. (Refused)

[IF EV1<>1, TERMINATE]

Program Marketing and Interactions

Q1. How did you first learn about <PROGRAM ADMINISTRATOR>'s gas heating rebate program?

01. (Contractor)
02. (<PROGRAM ADMINISTRATOR> mailing/letter)
03. (Bill insert)
04. (<PROGRAM ADMINISTRATOR> website)
05. (Family/friends/word of mouth)
06. (Retailer/Store)
07. (TV/radio/newspaper/other mass media)
00. (Other, please specify)
98. (Don't know)
99. (Refused)

[ASK IF Q1<>1]

Q2a. Did your contractor talk to you about <PROGRAM ADMINISTRATOR>'s gas heating rebate program?

1. Yes
2. No
8. (Don't know)
9. (Refused)

[ASK IF Q1<>2,3]

Q2b. Did you receive any marketing or informative materials or see any advertising from <PROGRAM ADMINISTRATOR> about the benefits of energy efficient heating equipment or available rebates?

1. Yes
2. No
8. (Don't know)
9. (Refused)

[ASK IF Q1<>4]

Q2c. Did you visit <PROGRAM ADMINISTRATOR>'s website to learn more about the benefits of energy efficient heating equipment or available rebates?

1. Yes
2. No
8. (Don't know)
9. (Refused)

Q3. Did you receive a tax credit or rebate from the government for the heating equipment that you installed?

1. Yes
2. No
8. (Don't know)
9. (Refused)

Equipment Verification

I now have a few questions about the energy efficient measures for which you received a rebate from <PROGRAM ADMINISTRATOR>.

EV2. Our records show that you received a rebate from <PROGRAM ADMINISTRATOR> for the following improvements. Could you confirm that you installed… [1=Yes, 2=No, 8=Don't Know, 9=Refused]

a. <ECM>+<FURN> furnaces
b. <STM> steam boilers
c. <WTR> hot water boilers
d. <IWH> indirect water heaters
e. <TSTAT> programmable thermostats
f. <RESET> boiler reset controls

[ASK EV3a if EV2a=2, EV3b if EV2b=2, ETC.]

EV3. How many… did you receive a rebate for? [1=Yes, 2=No, 8=Don't Know, 9=Refused]

a. Furnaces
b. Steam boilers
c. Hot Water boilers
d. Indirect water heaters
e. Programmable thermostats
f. Boiler reset controls

[GENERATE V_FURN, V_STM, V_WTR, V_IWH, V_TSTAT, V_RESET BASED ON VERIFIED NUMBER OF MEASURES FROM EV2/EV3]

[READ IF NEEDED: AN INDIRECT WATER HEATER IS A DEVICE THAT PROVIDES HOT WATER TO THE HOME USING YOUR FURNACE OR BOILER AS A HEAT SOURCE]

[READ IF NEEDED: A BOILER RESET CONTROL IS AN AUTOMATED DEVICE THAT ADJUSTS THE TEMPERATURE OF YOUR BOILER BASED ON OUTSIDE TEMPERATURE IN ORDER TO OBTAIN HIGHER EFFICIENCY]

[READ IF NEEDED: DUCT AND AIR SEALING IS THE PROCESS OF IDENTIFYING AND FILLING HOLES IN THE FLOORS, WALLS, CEILINGS, AND DUCTS OF A HOME TO PREVENT WARM AIR LEAKAGE]

[SELECT TWO MEASURES TO ASK ABOUT BASED ON PER-MEASURE QUOTAS AND SAVINGS. FOR THE PURPOSES OF THIS SECTION, FURNACES AND FURNACES WITH ECMS WILL BE COMBINED. ONE MEASURE WILL ALWAYS BE A MAJOR MEASURE (FURNACE OR BOILER) IF THE PROJECT INCLUDED ONE. ASSIGN THESE MEASURES TO <MEAS1> AND <MEAS2>. ASSIGN THEIR QUANTITIES TO <V_QTY1> <V_QTY2> RESPECTIVELY]

Free-Ridership

Next, I have a few questions about the decision-making process that led you to install new energy efficient heating equipment at <ADDRESS>.
[LOOP FOR <MEAS1> AND <MEAS2>]

For the next few questions, please think about the <Meas> you installed.

[ASK IF <MEAS> = FURN,STM,WTR ELSE SKIP TO FR2A]

[READ IF V_QTY>1 – IF NOT READ, PLEASE INSERT THIS AS AN INTERVIEWER NOTE ON FR0a-FR0j]
If the <Meas>s replaced more than one heating system, please think about the primary heating system you replaced when answering these questions. [INTERVIEWER NOTE: IF THEY SAY BOTH HEATING SYSTEMS WERE PRIMARY, ASK THEM TO PICK ONE OF THEM]

FR0a. When you installed your new gas <Meas> did you switch to gas heat from another fuel?
- 1. Yes
- 2. No
- 3. (New home) [SKIP TO FR2a]
- 8. (Don't know)
- 9. (Refused)

[ASK IF FR0a=1]
FR0b. Which fuel did you switch from?
- 1. Oil
- 2. Electric
- 00. (Other, specify)
- 98. (Don't know)
- 99. (Refused)

FR0c. At the time that you replaced your old heating system with a <MEAS> through the <PROGRAM ADMINISTRATOR> program, was your old heating system still working?
- 1. Yes
- 2. No
- 3. (New home) [SKIP TO FR2a]
- 8. (Don't know)

9. (Refused)

[ASK IF FR0c=1]
FR0d. Which of the following best describes the condition of your old heating system?
1. The old system was working with no need of repair
2. The old system was working with need of minor repair
3. The old system was working with need of major repair
8. (Don’t know)
9. (Refused)

[ASK IF FR0c=2,8 or 9]
FR0e. Was your old heating system repairable or was it beyond repair?
1. Repairable
2. Beyond repair
8. (Don’t know)
9. (Refused)

[ASK IF FR0e=1]
FR0f. Would this have been a major or minor repair?
1. Major repair
2. Minor repair
8. (Don’t know)
9. (Refused)

FR0g. How many years old was your existing heating system?
(NUMERIC OPEN END)
998. (Don’t know)
999. (Refused)

[ASK IF FR0g=998]
FR0h. What would you estimate the approximate age of your old heating system to be?
1. Less than 2 years
2. Between 2 and 5 years
3. Between 5 and 10 years
4. Between 10 and 15 years
5. Between 15 and 20 years
6. Or more than 20 years
8. (Don’t know)
9. (Refused)

[ASK IF FR0c=2 OR FR0c=8 OR FR0c=9 OR (FR0c=1 AND FR0d=3)]

FR0i. Why did you decide to install the HIGH EFFICIENCY <MEAS>? [ENTER ALL THAT APPLY]

01. (Old equipment could not be repaired)
02. (Old equipment was too old and not worth fixing)
03 (Repairs required to fix the old equipment were too high)
04. (To increase efficiency level)
05. (Wanted to add heating to house/room)
06. (Part of a new addition to the house)
07. (I thought the rebate might not be there when my unit failed in the future)
08. (Contractor indicated the unit would fail soon)
09. (Wanted to save money on utility bills)
00. (Other, specify)
98. (Don't know)
99. (Refused)

[ASK IF FR0c=1 AND FR0d<>3]

FR0j. Why did you decide to replace your former heating system while it was still functional? [OPEN END]

FR2a. Were you already planning to install a new <MEAS> when you learned that you could receive a rebate from <PROGRAM ADMINISTRATOR>?

1. Yes
2. No
8. (Don't know)
9. (Refused)

[ASK IF FR2a=1 & MEASURE = FURN, STM, WTR, ELSE SKIP TO FR4]

FR2b. Were you already planning to install a HIGH EFFICIENCY <MEAS> when you learned that you could receive a rebate from <PROGRAM ADMINISTRATOR>?

1. Yes
2. No
8. (Don't know)
9. (Refused)

FR4. Using a scale of 1 to 7, where 1 means no influence and 7 means a great deal of influence, please rate the influence of the following on your decision to install a [READ IN "HIGH EFFICIENCY" IF MEASURE TYPE = FURN, STM, WTR] <MEAS>. (If needed: Using a scale of 1 to 7, where 1 means no influence and 7 means a great deal of influence, please rate the influence of this factor on your decision to install the [READ IN "HIGH EFFICIENCY" IF MEASURE TYPE = FURN, STM, WTR] <MEAS>)

a. Contractor recommendations
b. [ASK IF Q2B=1 OR Q2C=1 OR Q1=2,3,4] Information from <PROGRAM ADMINISTRATOR>'s marketing materials [IF Q2C=1, READ "AND WEBSITE"]
c. The <PROGRAM ADMINISTRATOR> rebate

FR9. How likely is it that you would have installed [READ IN "THE SAME EFFICIENCY HEATING EQUIPMENT" IF MEASURE TYPE = FURN, STM, WTR] [READ IN "THE <MEAS>" IF MEASURE TYPE = TSTAT, RESET, SEAL, IWH] if you had not received a rebate from <PROGRAM ADMINISTRATOR>? Please use a 1 to 7 point scale where 1 is "not at all likely" and 7 is "very likely." [RECORD 1-7; 98=DK; 99=REF]

[IF (FR4b = 7 OR FR4c = 7) AND FR9=1, SKIP TO END OF LOOP]

FR5. Did the availability of the <PROGRAM ADMINISTRATOR> rebate cause you to install your [READ IN "HIGH EFFICIENCY" IF MEASURE TYPE = FURN, STM, WTR] <MEAS> EARLIER than you would have on your own, or did the rebate have no influence on when you installed the equipment?

1. Installed earlier
2. Did not change when installed
3. (Would not have installed the equipment at all without rebate)
8. (Don't know)
9. (Refused)

[ASK IF FR5=3]

FR6. Just to confirm, without the <PROGRAM ADMINISTRATOR> rebate, you would NOT have installed your <MEAS> at all, is that correct?

1. Yes [SKIP TO FR10]
2. No
8. (Don't know)
9. (Refused)

[ASK IF FR5=1]

FR7. If the <PROGRAM ADMINISTRATOR> rebate had not been available, when would you have installed your [READ IN "HIGH EFFICIENCY" IF MEASURE TYPE = FURN, STM, WTR] <MEAS>? Would you say…

1. Within 6 months of when you did
2. 6 months to a year later
3. 1 to 2 years later
4. or more than 2 years later
8. (Don't know)
9. (Refused)

[ASK IF <V_QTY> >1 & MEAS<>SEAL]

FR8. If the <PROGRAM ADMINISTRATOR> rebate had not been available, would you still have installed <V_QTY> [READ IN "HIGH EFFICIENCY" IF MEASURE TYPE = FURN, STM, WTR] <MEAS>s or would you have installed fewer?

1. Same number
2. Fewer
8. (Don't know)
9. (Refused)

[ASK IF FR8=2]

FR8a. How many <MEAS> would you have installed if the rebate had not been available? [NUMERIC OPEN END, 98=DK, 99=REF]

[ASK IF (FR9>5 AND FR4C>5) OR (FR9<3 AND FR4C<3) OR (FR4c<3 AND FR6=1)]

FR10. Just to make sure I understand, please explain the importance of the rebate you received from <PROGRAM ADMINISTRATOR> on your decision to install the [READ IN "HIGH EFFICIENCY" IF MEASURE TYPE = FURN, STM, WTR] <MEASURE> [READ IN "INSTEAD OF LESS EFFICIENT EQUIPMENT" IF MEASURE TYPE = FURN, STM, WTR]. [OPEN END; 98=Don't know, 99=Refused]

[ASK IF Q3=1 AND MEASURE = FURN,STM,WTR, ELSE SKIP TO END OF LOOP]
You mentioned earlier that you received a rebate from <PROGRAM ADMINISTRATOR> AND a government tax credit or rebate for the installation of high efficiency heating equipment.

FR11. Using a 1 to 7 point scale where 1 is "not at all likely" and 7 is "very likely" how likely is it that you would have installed THE SAME EFFICIENCY heating equipment had neither tax rebates and credits nor <PROGRAM ADMINISTRATOR> rebate been available? [RECORD 1-7; 98=DK; 99=REF]

Spillover

Next, I would like to discuss any other energy efficient equipment you might have installed without a rebate at <ADDRESS>.

SO0. SINCE you received incentives from <PROGRAM ADMINISTRATOR> for energy efficient heating equipment, have you made any other energy efficient upgrades to the home for which you did NOT receive a rebate from <PROGRAM ADMINISTRATOR>?

1. Yes
2. No [SKIP TO DEMOGRAPHICS]
8. (Don't know) [SKIP TO DEMOGRAPHICS]
9. (Refused) [SKIP TO DEMOGRAPHICS]

I will now ask you some questions about specific upgrades you might have made. Please only think about upgrades you made AFTER you received the gas equipment rebate from <PROGRAM ADMINISTRATOR>.

<u>Insulation</u>

SO1. Did you insulate the home without receiving a rebate?

1. Yes
2. No [SKIP TO SO11]
8. (Don't know) [SKIP TO SO11]
9. (Refused) [SKIP TO SO11]

SO2. Why did you decide to add insulation? [OPEN END]

SO3. Did your experience with the <PROGRAM ADMINISTRATOR> high efficiency gas heating program encourage you IN ANY WAY to insulate the home? [OPEN END]

1. Yes
2. No [SKIP TO SO11]
8. (Don't know) [SKIP TO SO11]
9. (Refused) [SKIP TO SO11]

SO4. Using a scale of 1 to 7, where 1 is no influence and 7 is a great deal of influence, how much influence did your experience with the <PROGRAM ADMINISTRATOR> high efficiency gas heating program have on your decision to insulate the home? [RECORD 1-7; 98=DK; 99=REF]

[ASK IF S04>5, ELSE SKIP TO NEXT SECTION]

S05. Can you explain how your experience with the <PROGRAM ADMINISTRATOR> high efficiency gas heating program influenced your decision to insulate the home?

- 00. [OPEN END]
- 98. (Don't know)
- 99. (Refused)

S06. What parts of the home did you insulate?

- 01. Attic
- 02. Walls
- 00. (Other, specify)
- 98. (Don't know)
- 99. (Refused)

[ASK IF S06=1, ELSE SKIP TO SO11]

S07. What type of insulation did you use to insulate the attic? Was it..?

- 01. Blown in insulation
- 02. Layer or batting insulation
- 03. Spray foam insulation
- 00. or some other type?
- 98. (Don't know)
- 99. (Refused)

S08. Did you have any insulation in the attic before this insulation project?

1. Yes
2. No
8. (Don't know)
9. (Refused)

[ASK IF S08=1]

S09a. Approximately, how many inches of insulation did you have in the attic before the insulation project? [NUMERIC OPEN END, 98=DK, 99=REF] [PROBE FOR BEST ESTIMATE]

S09b. Approximately, how many inches of insulation were added as a result of the project? [NUMERIC OPEN END, 98=DK, 99=REF] [PROBE FOR BEST ESTIMATE]

[ASK IF S09a=98, 99 AND S08=1]

SO10a. What was the R-value of the insulation that you had in the attic before the insulation project? [NUMERIC OPEN END, 98=DK, 99=REF] [PROBE FOR BEST ESTIMATE]

[ASK IF S09b=98, 99]

SO10b. What is the R-value of the insulation that was added as a result of the project? [NUMERIC OPEN END, 98=DK, 99=REF] [PROBE FOR BEST ESTIMATE]

<u>Windows</u>

SO11. Did you install new windows in the home without receiving a rebate?

1. Yes
2. No [SKIP TO SO17]

8. (Don't know) [SKIP TO SO17]
9. (Refused) [SKIP TO SO17]

SO12. Why did you decide to install new windows? [OPEN END]

SO13. Did your experience with the <PROGRAM ADMINISTRATOR> high efficiency gas heating program encourage you IN ANY WAY to install new windows in the home? [OPEN END]
1. Yes
2. No [SKIP TO SO17]
8. (Don't know) [SKIP TO SO17]
9. (Refused) [SKIP TO SO17]

SO14. Using a scale of 1 to 7, where 1 is no influence and 7 is a great deal of influence, how much influence did your experience with the <PROGRAM ADMINISTRATOR> high efficiency gas heating program have on your decision to install new windows? [RECORD 1-7; 98=DK; 99=REF]

[ASK IF SO14>5, ELSE SKIP TO SO17]
SO15. Can you explain how your experience with the <PROGRAM ADMINISTRATOR> high efficiency gas heating program influenced your decision to install new windows?
00. [OPEN END]
98. (Don't know)
99. (Refused)

SO16. How many windows did you install? [NUMERIC OPEN END, 98=DK, 99=REF]

Energy Star Refrigerators

SO17. Did you purchase an ENERGY STAR refrigerator without receiving a rebate?
1. Yes
2. No [SKIP TO SO23]
8. (Don't know) [SKIP TO SO23]
9. (Refused) [SKIP TO SO23]

SO18. Why did you decide to purchase an ENERGY STAR refrigerator instead of a NON-ENERGY STAR refrigerator? [OPEN END]

SO19. Did your experience with the <PROGRAM ADMINISTRATOR> high efficiency gas heating program encourage you IN ANY WAY to purchase an ENERGY STAR refrigerator?
1. Yes
2. No [SKIP TO SO23]
8. (Don't know) [SKIP TO SO23]
9. (Refused) [SKIP TO SO23]

SO20. Using a scale of 1 to 7, where 1 is no influence and 7 is a great deal of influence, how much influence did your experience with the <PROGRAM ADMINISTRATOR> high efficiency gas heating program have on your decision to purchase an ENERGY STAR refrigerator? [RECORD 1-7; 98=DK; 99=REF]

[ASK IF SO20>5, ELSE SKIP TO SO23]

SO21. Can you explain how your experience with the <PROGRAM ADMINISTRATOR> high efficiency gas heating program influenced your decision to purchase an ENERGY STAR refrigerator?

00. [OPEN END]
98. (Don't know)
99. (Refused)

SO22. What type of ENERGY STAR refrigerator did you get? Does it have..?

1. A top-mounted freezer
2. A bottom-mounted freezer or
3. A side-by-side freezer
8. (Don't know)
9. (Refused)

<u>Energy Star Clothes Washers</u>

SO23. Did you purchase an ENERGY STAR clothes washer without receiving a rebate?

1. Yes
2. No [SKIP TO SO28]
8. (Don't know) [SKIP TO SO28]
9. (Refused) [SKIP TO SO28]

SO24. Why did you decide to purchase an ENERGY STAR clothes washer instead of a NON-ENERGY STAR clothes washer? [OPEN END]

SO25. Did your experience with the <PROGRAM ADMINISTRATOR> high efficiency gas heating program encourage you IN ANY WAY to purchase an ENERGY STAR clothes washer?

1. Yes
2. No [SKIP TO SO28]
8. (Don't know) [SKIP TO SO28]
9. (Refused) [SKIP TO SO28]

SO26. Using a scale of 1 to 7, where 1 is no influence and 7 is a great deal of influence, how much influence did your experience with the <PROGRAM ADMINISTRATOR> high efficiency gas heating program have on your decision to purchase an ENERGY STAR clothes washer? [RECORD 1-7; 98=DK; 99=REF]

[ASK IF SO26>5, ELSE SKIP TO SO28]

SO27. Can you explain how your experience with the <PROGRAM ADMINISTRATOR> high efficiency gas heating program influenced your decision to purchase an ENERGY STAR clothes washer?

00. [OPEN END]
98. (Don't know)
99. (Refused)

[SKIP TO SO36 IF WATER HEATER FLAG=1]

<u>Water Heating</u>

SO28. Did you purchase a new water heating system without receiving a rebate?

1. Yes

2. No [SKIP TO S036]
8. (Don't know) [SKIP TO S036]
9. (Refused) [SKIP TO S036]

S029. Why did you decide to purchase a new water heating system? [OPEN END]

S030. Did your experience with the <PROGRAM ADMINISTRATOR> high efficiency gas heating program encourage you IN ANY WAY to purchase a new water heating system?

1. Yes
2. No [SKIP TO S034]
8. (Don't know) [SKIP TO S034]
9. (Refused) [SKIP TO S034]

S031. Using a scale of 1 to 7, where 1 is no influence and 7 is a great deal of influence, how much influence did your experience with the <PROGRAM ADMINISTRATOR> high efficiency gas heating program have on your decision to purchase a new water heating system? [RECORD 1-7; 98=DK; 99=REF]

[ASK IF S031>5, ELSE SKIP TO S034]
S032. Can you explain how your experience with the <PROGRAM ADMINISTRATOR> high efficiency gas heating program influenced your decision to purchase a new water heating system?

00. [OPEN END]
98. (Don't know)
99. (Refused)

S033. What type of water heating system did you purchase?

1. Storage hot water heater
2. On-demand hot water heater
00. (Other, specify)
98. Don't know
99. Refused

[ASK IF S033>1, ELSE SKIP TO S035]
S034. What size tank does your new water heating system have?
[NUMERIC OPEN END, 98=DK, 99=REF]

S035. What fuel does your new water heating system use?

1. Gas
2. Electricity
00. (Other, specify)
98. Don't know
99. Refused

<u>Low-Flow Shower Heads</u>

S036. Did you install low-flow showerheads without receiving a rebate?

1. Yes
2. No [SKIP TO S042]
8. (Don't know) [SKIP TO S042]
9. (Refused) [SKIP TO S042]

SO37. Why did you decide to install low-flow showerheads? [OPEN END]

SO38. Did your experience with the <PROGRAM ADMINISTRATOR> high efficiency gas heating program encourage you IN ANY WAY to install low-flow showerheads?
1. Yes
2. No [SKIP TO SO42]
8. (Don't know) [SKIP TO SO42]
9. (Refused) [SKIP TO SO42]

SO39. Using a scale of 1 to 7, where 1 is no influence and 7 is a great deal of influence, how much influence did your experience with the <PROGRAM ADMINISTRATOR> high efficiency gas heating program have on your decision to install low-flow showerheads? [RECORD 1-7; 98=DK; 99=REF]

[ASK IF SO39>5, ELSE SKIP TO SO42]
SO40. Can you explain how your experience with the <PROGRAM ADMINISTRATOR> high efficiency gas heating program influenced your decision to install low-flow showerheads?
00. [OPEN END]
98. (Don't know)
99. (Refused)

SO41. How many low-flow showerheads did you install? [NUMERIC OPEN END, 98=DK, 99=REF]

<u>Faucet Aerators</u>

SO42. Did you install faucet aerators without receiving a rebate?
1. Yes
2. No [SKIP TO SO48]
8. (Don't know) [SKIP TO SO48]
9. (Refused) [SKIP TO SO48]

SO43. Why did you decide to install faucet aerators? [OPEN END]

SO44. Did your experience with the <PROGRAM ADMINISTRATOR> high efficiency gas heating program encourage you IN ANY WAY to install faucet aerators?
1. Yes
2. No [SKIP TO SO48]
8. (Don't know) [SKIP TO SO48]
9. (Refused) [SKIP TO SO48]

SO45. Using a scale of 1 to 7, where 1 is no influence and 7 is a great deal of influence, how much influence did your experience with the <PROGRAM ADMINISTRATOR> high efficiency gas heating program have on your decision to install faucet aerators? [RECORD 1-7; 98=DK; 99=REF]

[ASK IF S045>5, ELSE SKIP TO S048]

S046. Can you explain how your experience with the <PROGRAM ADMINISTRATOR> high efficiency gas heating program influenced your decision to install faucet aerators?

00. [OPEN END]
98. (Don't know)
99. (Refused)

S047. How many faucet aerators did you install…

a. In bathrooms
b. In kitchens

[NUMERIC OPEN END, 98=DK, 99=REF]

[ASK IF S039>5 OR S045>5]

S048. How many bathrooms are in the home? [NUMERIC OPEN END, 98=DK, 99=REF]

[ASK IF S026>5 OR S039>5 OR S045>5]

S049. What fuel do you use to heat water in the home?

1. Electricity
2. Gas
3. Oil
00. Other, specify
98. (Don't know)
99. (Refused)

S050. Have you made any other energy efficient upgrades to the home for which you did NOT receive a rebate from <PROGRAM ADMINISTRATOR>?

1. Yes
2. No [SKIP TO DEMOGRAPHICS]
8. (Don't know) [SKIP TO DEMOGRAPHICS]
9. (Refused) [SKIP TO DEMOGRAPHICS

S051. Please describe these upgrades. [OPEN END; 98=Don't know, 99=Refused]

S052. Why did you decide to make these upgrades? [OPEN END; 98=Don't know, 99=Refused]

S053. Did your experience with the <PROGRAM ADMINISTRATOR> high efficiency gas heating program encourage you IN ANY WAY to make these upgrades?

1. Yes
2. No [SKIP TO DEMOGRAPHICS]
8. (Don't know) [SKIP TO DEMOGRAPHICS]
9. (Refused) [SKIP TO DEMOGRAPHICS]

S054. Using a scale of 1 to 7, where 1 is no influence and 7 is a great deal of influence, how much influence did your experience with the <PROGRAM ADMINISTRATOR> high efficiency gas heating program have on your decision to make these upgrades? [RECORD 1-7; 98=DK; 99=REF]

[ASK IF SO54>5, ELSE SKIP TO DEMOGRAPHICS]
SO55. Can you explain how your experience with the <PROGRAM ADMINISTRATOR> high efficiency gas heating program influenced your decision to make these upgrades?
00. [OPEN END]
98. (Don't know)
99. (Refused)

Demographics

I only have a few general questions left.

D1a. Do you own or rent the home at <STREET>? (INTERVIEWER NOTE: IF RESPONDENT MENTIONS BEING LANDLORD, CATEGORIZE THEM UNDER OWN)
1. Own
2. Rent
00. (Other, specify)
98. (Don't know)
99. (Refused)

D2. Which of the following best describes the home?
1. Single-family detached home
2. Townhouse
3. Duplex or two-family home
4. Apartment, condominium or multifamily home with three or more units
00. (Other, specify)
98. (Don't know)
99. (Refused)

[ASK IF D2=4]
D2a. What floor is the unit on? [NUMERIC OPEN END, 98=DK, 99=REF]

D3. How many people currently live in the home year-round? Please exclude anyone who is just visiting or children who may be away at college or in the military, but include yourself if you live in the home. [NUMERIC OPEN END, 98=DK, 99=REF]

D4. What is the highest level of education a person still living in the home has completed?
1. Less than high school
2. Some high school
3. High school graduate or equivalent (e.g., GED)
4. Trade or technical school
5. Some college, no degree
6. College degree (e.g. Bachelor's degree)
7. Some graduate school
8. Graduate degree (e.g., Master's or Doctorate degree)
98. Don't know
99. Refused

D5. Which of the following best describes the household's total income in 2012? (IF NEEDED: This information is for classification purposes only)
1. Less than $25,000
2. $25,000 to less than $30,000
3. $35,000 to less than $50,000
4. $50,000 to less than $75,000
5. $75,000 to less than $100,000
6. $100,000 to less than $150,000
7. $150,000 to less than $200,000
8. $200,000 or more
98. Don't know
99. Refused

D6. INTERVIEWER: RECORD GENDER OF RESPONDENT (DO NOT READ)
1. Male
2. Female

Those are all the questions I have for today. Thank you for your time and help in this important study. We greatly appreciate your assistance.

Contractor Survey Instrument

SAMPLE VARIABLES:
<PA> –
<CONTACT> – Name of contact
<MEASURE1> – Furnace, Water Boiler, Steam Boiler, Indirect Water Heater flag for NTG & upfront
<MEASURE2> – Furnace, Water Boiler, Steam Boiler, Indirect Water Heater flag for NTG & upfront
<MEASURE3> – Furnace, Water Boiler, Steam Boiler, Indirect Water Heater flag for NTG & upfront
<MEASURE4>– Furnace, Water Boiler, Steam Boiler, Indirect Water Heater flag for NTG & upfront
<PA_MEAS_EE> - Measure efficiency definition by measure and PA

Introduction

[READ IF CONTACT AVAILABLE]

Hello, this is ________ from Opinion Dynamics. This is not a sales call. I am calling on behalf of <PA>. May I please speak with <CONTACT>?

We are conducting a brief survey with contractors who have installed residential gas heating equipment that received incentives through <PA>'s Gas Heating rebate program. We are trying to understand the influence of the program on the residential heating and water heating market in New York. The survey will take about 20 minutes of your time and, if you qualify and complete the survey, you will receive a $50 check as a token of our appreciation of your time. The information we gather will help improve energy efficiency programs in New York.
Are you the best person within your company to speak with?
[READ IF NEEDED: THE INFORMATION THAT YOU PROVIDE WILL REMAIN STRICTLY CONFIDENTIAL. IT WILL BE USED FOR RESEARCH PURPOSES ONLY.]

[READ IF CONTACT NOT AVAILABLE]

Hello, this is ________ from Opinion Dynamics. This is not a sales call. I am calling on behalf of <PA>. We are conducting a brief survey with contractors who have installed residential gas heating equipment that received incentives through <PA>'s Gas Heating rebate program. I would like to speak with the person most knowledgeable about your company's interactions with this program. The survey will take about 20 minutes of your time, and if you qualify and complete the survey, you will receive a $50 check as a token of our appreciation of your time.
The information we will gather will help improve energy efficiency programs in New York.
Are you the best person to speak with?

[READ IF NEEDED: THE INFORMATION THAT YOU PROVIDE WILL REMAIN STRICTLY CONFIDENTIAL. IT WILL BE USED FOR RESEARCH PURPOSES ONLY.]

Screener

S1. Our records indicate that between 2009 and 2011, your company installed the following types of high efficiency heating equipment for which residential customers received an incentive through <PA>'s Gas Heating program. Could you confirm that you installed… [1=YES; 2=NO; 8=DON'T KNOW; 9=REFUSED]

a. Furnaces [SKIP IF <MEASURE1> = 0]
b. Hot Water Boilers [SKIP IF <MEASURE2> = 0]
c. Steam Boilers [SKIP IF <MEASURE3> = 0]
d. Indirect Water Heaters [SKIP IF <MEASURE4> = 0]

[TERMINATE IF NONE OF S1a-d=1]

S2. How knowledgeable would you say are you about <PA>'s Gas Heating program?

1. Very knowledgeable
2. Somewhat knowledgeable
3. Not very knowledgeable
4. Not at all knowledgeable
8. (Don't know)
9. (Refused)

[TERMINATE IF S2=4,8,9]

Thank you, you qualify for this study and the $50 check upon completion of this survey.

[ASK ALL]

Firmographics

I first have a few questions about your company.

F1. Do you know what areas fall into <PA>'s gas service territory?

1. Yes
2. No
8. (Don't know)
9. (Refused)

[ASK IF F1=2,8,9]

F1a. [READ IN THE DEFINITION OF THE PA SERVICE TERRITORY]. For the remainder of the questions I will refer to this area as <PA>'s service territory.

F2. Approximately, what percent of your company's business is in <PA>'s service territory? [RECORD PERCENT 0% TO 100%; 998=DON'T KNOW; 999=REFUSED] [PROBE IF NEEDED – YOUR BEST ESTIMATE IS FINE]

F3. How many employees does your company have? [NUMERIC OPEN END 1 TO 9,000; 9998=DON'T KNOW; 9999=REFUSED]

F4. What is your job title?
1. (Owner/President)
2. (Vice President)
3. (Chief Executive Officer)
4. (Office Manager)
5. (Bookkeeper)
6. (Branch Manager)
7. (Director)
8. (Project Manager)
9. (Sales Executive)
10. (Installation Manager)
00. (Other, specify)
98. (Don't know)
99. (Refused)

For the following questions, I would like you to focus on installations ONLY IN RESIDENTIAL buildings and the work that you do ONLY in <PA>'s service territory.

Warm-Up Questions

[CALCULATE <MEASURE>. IF MEASURE1 IS CONFIRMED THAN <MEASURE>=MEASURE1. IF MEASURE1 IS NOT CONFIRMED <MEASUREE> =MEASURE2, ETC.]

The next few questions will be about <MEASURE>s. I will be asking you about various efficiency levels of <MEASURE>. When I say "high efficiency," I mean...

[READ IN <MEASURE> WITH EFFICIENCY OF <PA_MEAS_EE>% AFUE]

Our study includes the period from 2009 to 2011. Some of our questions will be specific to that period. If you can't answer those questions for that period, please answer for a typical recent year.
Let's start with a few questions about your customers.

W1. In general, what percentage of your CURRENT customers have already decided on a specific product before contacting you for new equipment? [RECORD PERCENT 0% TO 100%; 998=DON'T KNOW; 999=REFUSED]

[ASK IF W1>0%]
W2. Of those customers, what percentage SPECIFICALLY request high efficiency <MEASURE>? [RECORD PERCENT 0% TO 100%; 998=DON'T KNOW; 999=REFUSED]

[ASK IF W1 <> 998, 999]
W3. Have these percentages changed compared to the period between 2009 and 2011?
1. Yes – have changed
2. No – didn't change
8. (Don't know)
9. (Refused)

[ASK IF W3=1]
W4. Between 2009 and 2011, what percent of your customers had already decided on a specific product before contacting you for new equipment? [RECORD PERCENT 0% TO 100%; 998=DON'T KNOW; 999=REFUSED]

[ASK IF W4>0%]
W5. And what percent of those customers SPECIFICALLY requested high efficiency <MEASURE>? [RECORD PERCENT 0% TO 100%; 998=DON'T KNOW; 999=REFUSED]

W6. Over the past few years, has it become easier or harder to sell high efficiency <MEASURE> to your customers, or has there been no change?
1. Easier
2. No change
3. Harder
8. (Don't know)
9. (Refused)

W7. Over the past few years, has it become easier or harder to obtain high efficiency <MEASURE> from distributors, or has there been no change?
1. Easier
2. No change
3. Harder
8. (Don't know)
9. (Refused)

W9. In what percentage of sales situations do you recommend high efficiency <MEASURE> to your customers? [RECORD PERCENT 0% TO 100%; 998=DON'T KNOW; 999=REFUSED] [PROBE IF NEEDED – YOUR BEST ESTIMATE IS FINE]

[AS IF W9>0%]
W11. And in cases when you recommend high efficiency <MEASURE> to your customers, in what percent do you also present them with a less efficient option? [RECORD PERCENT 0% TO 100%; 998=DON'T KNOW; 999=REFUSED]

Equipment Stocking Questions

I now have a few questions about your practices of stocking heating equipment.

ST1. In general, do you keep an inventory of <MEASURE> or do you order them in response to customer orders?
1. I keep inventory of <MEASURE>
2. I order <MEASURE> on an as-needed basis as customers order them
00. (Other, specify)
98. Don't know
99. Refused

[ASK IF ST1=1, ELSE SKIP TO INTRO TO FR1]
ST2. Approximately, how many <MEASURE> do you typically have in inventory? [NUMERIC OPEN END; 998=DON'T KNOW, 999=REFUSED]

ST3. Has <PA>'s Gas Heating program affected the quantity of <MEASURE> you keep in inventory? [IF NEEDED: <PA>'s Gas Heating program began in 2009.]
1. Yes
2. No
8. (Don't know)
9. (Refused)

[ASK IF ST3=1
ST4. In what way? [OPEN END]

ST5. Has <PA>'s Gas Heating program affected the efficiency level of <MEASURE> you keep in inventory?
1. Yes
2. No
8. (Don't know)
9. (Refused)

[ASK IF ST5=1]
ST6. In what way? [OPEN END]

ST7. Did recent major weather events, such as Hurricanes Irene and Sandy or Tropical Storm Lee, affect your equipment inventory practices in any way?
1. Yes
2. No
8. (Don't know)
9. (Refused)

[ASK IF ST7=1]

ST8. In what way? [OPEN END]

Free-Ridership Adjustment Questions [ASK IF FR_FLAG=1, ELSE SKIP TO IC1]

Now, I would like for you to think back to 2009 and 2011, and I would like to discuss the way you specified and recommended <MEASURE> to your customers in 2009, and how your recommendations changed over the course of 2010 and 2011.
[IF RESPONDENT CAN'T ANSWER FOR 2009 TO 2011, ASK ABOUT THE PAST FEW YEARS]

FR1. Since <PA>'s gas rebate program began in 2009, how have the following three aspects changed? For each, please tell me if it improved greatly, improved somewhat, improved a little, or did not improve. [1=IMPROVED GREATLY, 2=IMPROVED SOMEWHAT, 3=IMPROVED A LITTLE, 4=DID NOT IMPROVE, 8=DON'T KNOW, 9=REFUSED]
a. Your knowledge of high efficiency options
b. Your comfort level with discussing the benefits of high efficiency with your customers
c. Your confidence level in recommending high efficiency options

[READ IF ANY IN FR1=1,2,3, ELSE SKIP TO FR7]
There could be multiple factors that might have played a role in the changes that you just mentioned. I would like you to rate the influence of the <PA>'s program as opposed to other factors. By PROGRAM INFLUENCE I mean the program incentive and any training, information, or other support that the program provided. By OTHER, NON-PROGRAM FACTORS I mean such things as changes in codes and standards, customers

requesting specific equipment, increased customer awareness, federal tax rebates and credits, and other factors not related to the program.

[ASK IF FR1a=1,2,3]

FR2. Now, using a scale of 1 to 7, where 1 is not at all influential and 7 is very influential, how influential ...

- a. was THE PROGRAM on increasing your knowledge of high efficiency options?
- b. were OTHER NON-PROGRAM factors on increasing your knowledge of high efficiency options?

[ASK IF FR1b=1,2,3]

FR3. How influential ...

- a. was THE PROGRAM on increasing your comfort level with discussing the benefits of high efficiency with your customers?
- b. were OTHER NON-PROGRAM factors on increasing your comfort level with discussing the benefits of high efficiency with your customers?

[ASK IF FR1c=1,2,3]

FR4. How influential ...

- a. was THE PROGRAM on increasing your confidence level in recommending high efficiency options?
- b. were OTHER NON-PROGRAM factors on increasing your confidence level in recommending high efficiency options?

[ASK IF (FR2a>4 AND FR2b>4)

FR6a. You mentioned that both the program and other non-program factors were of influence on increasing your KNOWLEDGE of high efficiency options. Please explain in your own words what the influence of the program was. [OPEN END]

[ASK IF (FR3a>4 AND FR3b>4

FR6b. You mentioned that both the program and other non-program factors were of influence on increasing your COMFORT LEVEL with discussing the benefits of high efficiency with your customers. Please explain in your own words what the influence of the program was. [OPEN END]

[ASK IF (FR4a>4 AND FR4b>4)

FR6c. You mentioned that both the program and other non-program factors were of influence on increasing your CONFIDENCE LEVEL in recommending high efficiency options. Please explain in your own words what the influence of the program was. [OPEN END]

FR7. Since <PA>'s Gas Heating program began in 2009, has the frequency with which you recommend high efficiency <MEASURE> increased, decreased, or stayed the same?

1. (Increased)
2. (Decreased)
3. (Stayed the same)
8. (Don't know)
9. (Refused)

[ASK IF FR7=1]

FR8. Approximately, what was the percent increase? [RECORD PERCENT 0% TO 100%; 998=DON'T KNOW; 999=REFUSED]

[ASK IF FR8>0% & <> 998, 999]

FR9. On a scale of 1 to 7, where 1 is not at all influential and 7 is very influential, how influential was <PA>'s Gas Heating program in the increase? [1-7; 8=DON'T KNOW; 9=REFUSED]

[ASK IF FR8>0%]

FR10. And how influential were the other factors not related to the program in the increase? Please use a scale of 1 to 7, where 1 is not at all influential and 7 is very influential. [1-7; 8=DON'T KNOW; 9=REFUSED]

[ASK IF FR9>4 AND FR10>4]

FR11. You mentioned that both the program and other non-program factors were of influence in increasing the frequency with which you recommend high efficiency <MEASURE>s. Please explain in your own words what the influence of the program was. [OPEN END]

[REPEAT FR12 and FR13 FOR OTHER MEASURES VERIFIED IN S1]

We just discussed <MEASURE> in detail. I would like to discuss <MEASURE2-5> and understand if your recommendations of this equipment type were similar or different. When thinking about high efficiency <MEASURE2-5>, please think about <DESCRIPTION OF HIGH EFFICIENCY>.

FR12. Have the changes in your recommendation of high efficiency <MEASURE2-5> been the same as or different from <MEASURE> that we just discussed?

1. Same
2. Different
8. (Don't know)
9. (Refused)

[ASK IF FR12=1]

FR13. And has the influence of the program on that change been the same as or different from the influence of the program on your recommendations of <MEASURE>?

1. Same
2. Different
8. (Don't know)
9. (Refused)

[ASK ALL]

Program Influence on Sales and Installations

I'd now like to ask you a few questions about your company's installations of <MEASURE>.

I1. How many <MEASURE> did your company install in <PA>'s service territory between 2009 and 2011? We are interested in all systems, not just energy efficient systems. [NUMERIC OPEN END; 99998=DON'T KNOW; 99999=REFUSED]
[PROBE IF NEEDED: YOUR BEST ESTIMATE IS FINE]

[ASK IF I1<>0; ALSO ASK IF DK/REFUSED]
[SKIP IF MEASURE=INDIRECT WATER HEATER]

I2. Now, if you were to divide all of your company's installations of <MEASURE>s in <PA>'s service territory between 2009 and 2011 across the following AFUE levels, what percentage of your installations were..? [RECORD PERCENT 0% TO 100%; 998=DON'T KNOW; 999=REFUSED]
[PLACE ALL RESPONSES ON ONE SCREEN]
[PROBE IF NEEDED: YOUR BEST ESTIMATE IS FINE]
a. <MEASURE> with AFUE below <PA_MEAS_EE>%
b. <MEASURE> with AFUE of <PA_MEAS_EE>% or higher

[ASK IF I2 DOES NOT SUM UP TO 100%]

I2CHK. The percentage breakdown you just provided by AFUE level does not equal 100%. To make sure we have the most accurate information, let me go back and go over the percentages with you one more time. [GO BACK TO I2]

[ASK IF I2b>0 AND NOT DK/REF]

I3. What percentage of your company's installations of <MEASURE>s with AFUE of <PA_MEAS_EE>% or higher received incentives through <PA>'s Gas Heating program? [RECORD PERCENT 0% TO 100%; 998=DON'T KNOW; 999=REFUSED] [PROBE IF NEEDED: YOUR BEST ESTIMATE IS FINE]

[ASK IF I3>0 AND NOT DK/REF]

I6. If the Gas Heating program incentives, marketing, and support had not existed, what percentage of the <MEASURE>s that received a rebate through the <PA> program do you think you would still have installed? [RECORD PERCENT 0% TO 100%; 998=DON'T KNOW; 999=REFUSED]

[ASK IF I6 NOT DK/REF]

I7. Why do you say that? [OPEN END]

[ASK IF INC_COST_FLAG = 1, ELSE SKIP TO PA1]

Incremental Cost Battery

Next, I would like to ask you a few questions about the pricing of different pieces of equipment. In this section, we are interested in the cost TO THE CUSTOMER, rather than the cost of equipment to you. In each of the following questions, I am going to present you with various efficiency levels for equipment a customer could install, and ask you how much each type would cost. Please consider the entire installed cost to a typical customer, including cost of the equipment, cost of any associated materials, and cost of labor.

[SKIP TO IC2 IF S1A=2,8,9,SYSMIS]
Let's first talk about furnaces.

IC1. What is the cost to a typical customer to install a furnace rated at… AFUE? (IF NEEDED: Please consider the entire cost to a typical customer, including labor, cost of the equipment, and cost of any associated materials.) [NUMERIC OPEN END 0-99999; 9997=Don't install this type of equipment; 99998=DON'T KNOW; 99999=REFUSED]

a. 78%
b. 90%
c. 92%
d. 94%
e. 95%

[SKIP TO IC3 IF S1B=2,8,9,SYSMIS]

Let's now talk about water boilers.

IC2. What is the cost in dollars to a typical customer to install a water boiler rated at… AFUE? Please consider the entire cost to a typical customer, including labor, cost of the equipment, and cost of any associated materials. [NUMERIC OPEN END 0-99999; 9997=Don't install this type of equipment; 99998=DON'T KNOW; 99999=REFUSED]

a. 80%
b. 85%
c. 90%

[SKIP TO IC4 IF S1C=2,8,9,SYSMIS]

My next questions are about steam boilers.

IC3a. What is the cost in dollars to a typical customer to install a steam boiler rated at… AFUE? Please consider the entire cost to a typical customer, including labor, cost of the equipment, and cost of any associated materials. [NUMERIC OPEN END 0-99999; 9997=Don't install this type of equipment; 99998=DON'T KNOW; 99999=REFUSED]

a. 75%
b. 81%
c. 82%

[SKIP TO PA1 IF S1D=2,8,9,SYSMIS]

My final price questions are about hot water heaters.

IC4a. What is the cost in dollars to a typical customer to install a STANDARD EFFICIENCY storage gas hot water heater (a gas water heater rated roughly a 0.53 Energy Factor)? Please consider the entire cost to a typical customer, including labor, cost of the equipment, and cost of any associated materials. [NUMERIC OPEN END 0-9999; 9997=Don't install this type of equipment; 9998=DON'T KNOW; 9999=REFUSED]

IC4b. What is the cost in dollars to a typical customer to install an indirect water heater? Please consider the entire cost to a typical customer (if needed: labor, cost of the equipment, and cost of any associated materials), including any additional labor costs or costs of associated materials specific to installing an indirect unit. [NUMERIC OPEN END 0-9999; 9997=Don't install this type of equipment; 9998=DON'T KNOW; 9999=REFUSED]

[ASK ALL]

Early Replacement

ER1. Between 2009 and 2011, approximately what percentage of your installations in existing homes included early replacement of the heating equipment even though the existing system was still functioning? [RECORD PERCENT 0% TO 100%; 998=DON'T KNOW; 999=REFUSED]

[ASK IF ER1>0 BUT NOT DK/REFUSED, ELSE SKIP TO THE NEXT SECTION]
ER2. On average, how much longer would these systems have operated if they were not replaced? [INTERVIEWER PLEASE RECORD IN YEARS AND MONTHS] [NUMERIC OPEN END] [PROBE FOR BEST ESTIMATE] [IF NEEDED: PROBE FOR AVERAGE]

Program Awareness and Interactions

I would now like to ask you a few questions about your knowledge and interactions with <PA>'s Gas Heating program and then we will be done.

PA1. In what year did your company start performing installations that received rebates through the program?
1. (Prior to 2009)
2. (2009)
3. (2010)
4. (2011)
5. (2012 and later)
7. (When the program first started)
8. (Don't know)
9. (Refused)

PA2. Thinking back to the timeframe between 2009 and 2011, do you remember any of the following? [1=YES; 2=NO; 8=DON'T KNOW; 9=REFUSED]
a. Receiving any marketing or promotional materials from <PA> related to the Gas Heating program?
b. Attending any training sessions, meetings, or events facilitated by <PA>?
c. Receiving any other support or information from the <PA>'s program?

[ASK IF ANY IN PA2=1]
PA7. And thinking about all information, marketing materials, and support that you might have received from the <PA>'s program, how helpful was it to each of the following...? Would you say it was of great help, some help, little help, or no help at all? [1= Great help, 2=Some help , 3= Little help, 4=No help, 8=Don't know, 9=Refused]
a. Increasing your ability to sell and promote high efficiency equipment to customers?
b. Improving your knowledge of energy efficient equipment options?

Distributor Contact Information

As part of our research effort, we are also looking to conduct interviews with equipment distributors.

D1. Would you be able to share the contact information of the distributor or distributors that you have been working with over the course of 2009 and 2011, so that we could contact them and conduct interviews with them? [YES, NO, DON'T KNOW, REFUSED]

Distributor 1	Distributor 2	Distributor 3	Distributor 4
Company name	Company name	Company name	Company name
Contact name	Contact name	Contact name	Contact name
Contact phone number	Contact phone number	Contact phone number	Contact phone number
Contact email address	Contact email address	Contact email address	Contact email address

Closing

These are all the questions that I have for you.

C1. Would you prefer for the $50 check to be issued to you or would you prefer to donate it to the American Red Cross?
1. Issued to respondent
2. American Red Cross
8. (Don't know)
9. (Refused)

[ASK IF C1=1]
GC3. Please tell me the name that the check should be issued to and the address where we should mail it.
a. [OPEN END, name]
b. [OPEN END, street number]
c. [OPEN END, street name]
d. [OPEN END, street suffix]
e. [OPEN END, city]
f. [OPEN END, zip]
99. (REFUSED) [TERMINATE]

Thank you very much again for your time. It is greatly appreciated. You should receive your check within the next 3 weeks. If you do not receive your check please call us at [PHONE]. Have a good day.

Distributor Interview Guide

Hello, my name is ________________ and I'm calling from Opinion Dynamics. We are conducting research for the New York utilities and energy efficiency program administrators. Specifically, we are trying to understand the impact of the gas heating programs that New York utilities are offering to their residential customers. In order to understand the market for residential gas heating equipment, we are conducting brief interviews with people like yourself who distribute residential heating and water heating equipment in the State of New York.

[IF APPLICABLE] <NAME> at <CONTRACTOR COMPANY> provided me with your name. He/she suggested that you would be really knowledgeable about New York's residential gas heating market and could help us understand the impact of the utility programs.

Is now a good time to talk? This should only take about 10 minutes, and I would like to emphasize that the information you provide will remain confidential and will be used for research purposes only.

Company Background

I first have a few questions about your company.

1. How many employees does your company have?

2a. Does your company supply heating equipment to all of New York State? [ASK IF NO] What areas do you service? (Probe: Upstate, downstate)

2b. Does your company sell equipment in other states?
[ASK IF YES]
   i. What other states?
   ii. Could you tell me approximately what percentage of your RESIDENTIAL gas heating systems are sold to contractors who are installing the equipment in New York State?

3. Which of the following types of residential gas heating equipment has your company sold in the past five years?
   a. Furnaces
   b. Water boilers
   c. Steam boilers
   d. Indirect water heaters
   e. ECM fans
   f. Boiler reset controls

Effects of HEHE Programs

4. How familiar, would you say, are you with the gas heating rebate programs offered to residential customers in New York? (Probe: Very, somewhat, not very, not at all)

[TERMINATE IF NOT AT ALL FAMILIAR WITH PROGRAMS]

5. We are interested in the impact that these programs may have had on both your overall sales volume as well as how those sales breakout between standard and high efficiency equipment.

a. Do you think that the New York programs have had an impact on your overall sales? Please explain.

b. Did they have any impact on the efficiency levels of the units that you are selling? Please explain.

[IF IMPACT ON SALES OR EFFICIENCY LEVELS IN QUESTION 6, ELSE SKIP TO Q.11]
I'd like to see if you can quantify some of the changes that you think the New York gas rebate programs have caused. I'm going to ask you some questions about the number of units you've sold and the share of those units that would be considered high efficiency. Our evaluation covers the period of 2009 to 2011. Would you be able to give me general estimates of equipment sales and efficiency levels for that time period? [ENTER RESPONSES IN TABLE 1]

[ASK FOR MEASURES DISTRIBUTOR INDICATES THEY SELL IN QUESTION 3]

6. Approximately how many <MEASURE> did you sell per year between 2009 and 2011? [ENTER RESPONSES IN TABLE 1]
   a. Furnaces
   b. Water boilers
   c. Steam boilers
   d. Indirect water heaters
   e. ECM fans
   f. Boiler reset controls

[ASK IF DISTRIBUTOR INDICATES THEY SELL FURNACES]

7a. In terms of efficiency level, what percentage of your furnace sales between 2009 and 2011 were…
   a. Less than 90% AFUE
   b. Between 90 and 91% AFUE
   c. 92% AFUE or greater

[ASK IF DISTRIBUTOR INDICATES THEY SELL WATER BOILERS]

7b. In terms of efficiency level, what percentage of your water boiler sales between 2009 and 2011 were…
   a. Less than 85% AFUE
   b. 85% AFUE or greater

[ASK IF DISTRIBUTOR INDICATES THEY SELL STEAM BOILERS]

7c. In terms of efficiency level, what percentage of your steam boiler sales between 2009 and 2011 were…
   a. Less than 82% AFUE
   b. 82% AFUE or greater

8. And how many <MEASURE> do you think you would have sold per year between 2009 and 2011 if the gas heating rebate programs had not been available? [ENTER RESPONSES IN TABLE 1]
   a. Furnaces
   b. Water boilers
   c. Steam boilers
   d. Indirect water heaters
   e. ECM fans

f. Boiler reset controls

[ASK IF DISTRIBUTOR INDICATES THEY SELL FURNACES]

9a. And of these furnaces, what percentage would have been…

a. Less than 90% AFUE
b. Between 90 and 91% AFUE
c. 92% AFUE or greater

[ASK IF DISTRIBUTOR INDICATES THEY SELL WATER BOILERS]

9b. And of these water boilers, what percentage would have been…

a. Less than 85% AFUE
b. 85% AFUE or greater

[ASK IF DISTRIBUTOR INDICATES THEY SELL STEAM BOILERS]

9c. And of these steam boilers, what percentage would have been…

a. Less than 82% AFUE
b. 82% AFUE or greater

10. Do you think the gas heating rebate programs in New York have influenced the efficiency level of heating equipment that manufacturers offer? Please explain.

11. Is there anything else you would like to say about how the New York gas rebate programs have impacted the market for high efficiency heating equipment in New York?

Those are all the questions I have for today. Thank you for your time and help in this important study.

Table 1. Units Sold and Shares by Efficiency Level

Equipment Type	Equipment Sales				
	Annual Units Sold		Efficiency Level	% Sales	
	2009-2011	2009-2011 (Hypothetical Without Program)		2009-2011	2009-2011 (Hypothetical Without Program)
Furnace			<90% AFUE		
			90/91% AFUE		
			92+% AFUE		
Water Boiler			*<85% AFUE*		
			85+% AFUE		
Steam Boiler			*<82% AFUE*		
			82+% AFUE		
Indirect Water Heater					
ECM Fan					
Boiler Reset Control					

Appendix D. Glossary of Terms

AFUE – Annual fuel utilization efficiency. A unitless measure of efficiency, representing a season-long average efficiency of a heating system, expressed as a percentage representing the ratio of useful energy output to energy input.

CATI – Computer-assisted telephone interviewing.

census stratum – In a stratified sample design, the stratum with those participants with the largest savings may have a calculated sample size that exceeds the population of the stratum. A stratum which meets this condition is referred to as a census stratum.

coefficient of variation (CV) - A normalized measure of dispersion of a probability distribution and defined as the ratio of the standard deviation, σ to the mean, μ:

$$c_v = \frac{\sigma}{\mu}$$

Con Edison – Consolidated Edison. This name is used throughout this report as shorthand for Consolidated Edison Company of New York, Inc.

confidence level – An indication of how close, expressed as a probability, the true value of the quantity in question is within a specified distance to the estimate of the value. Confidence is the likelihood that the evaluation has captured the true value of a variable within a certain estimated range.

deemed savings – An estimate of energy or demand savings for a single unit of an installed energy efficiency measure that (a) has been developed from data sources and analytical methods that are widely considered acceptable for the measure and purpose, and (b) is applicable to the situation being evaluated. Individual parameters or calculation methods can also be deemed.

DPS – New York Department of Public Service.

ECM, EC motor – Electronically commuted motor. An electrical motor requiring significantly less power to operate than a standard (alternating current) motor typically found in an HVAC system. Also often allows for better control over airflow and other benefits.

ESF – Energy savings factor. The ratio of the energy savings resulting from installation of a control (e.g., programmable thermostat, boiler reset control) to the annual energy use of heating or cooling equipment (e.g., furnace, boiler, central air conditioner).

ex post savings estimate, ex post impacts – Savings estimate reported by an evaluator after the energy impact evaluation has been completed.

free-rider, free-ridership (FR) – A program participant who would have implemented the program measure or practice in the absence of the program. Free-riders can be: 1) total, in which the participant's activity would have completely replicated the program measure; 2) partial, in which the participant's activity would have partially replicated the program measure; or 3) deferred, in which the participant's activity would have completely replicated the program measure, but at a future time than the program's timeframe.

gross savings – The change in energy consumption and/or demand that results directly from program-related actions taken by participants in an efficiency program, regardless of why they participated and unadjusted by any factors.

HEHE – High-efficiency heating and water heating.

incremental cost – The difference between the cost of existing or baseline equipment or service and the cost of alternative energy-efficient equipment or service.

KEDLI – Keyspan Energy Delivery Long Island. This acronym is used throughout this report to represent Keyspan Gas East Corporation.

KEDNY – Keyspan Energy Delivery New York. This acronym is used throughout this report to represent The Brooklyn Union Gas Company.

net savings – The total change in load that is attributable to an energy efficiency program. This change in load may include, implicitly or explicitly, the effects of free drivers, free-riders, energy efficiency standards, changes in the level of energy service, and other causes of changes in energy consumption or demand.

net-to-gross, net-to-gross ratio (NTG, NTGR) – A factor representing net program savings divided by gross program savings that is applied to gross program impacts to convert them into net program load impacts. The factor itself may be made up of a variety of factors that create differences between gross and net savings, commonly including free-riders and spillover. Other adjustments may include a correction factor to account for errors within the project-tracking data, breakage, and other factors that may be estimated which relate the gross savings to the net effect of the program. Can be applied separately to either energy or demand savings.

New York Technical Manual (NYTM) – The DPS-mandated reference document for calculating EEPS program savings.

NiMo – Niagara Mohawk. This acronym is used throughout this report to represent Niagara Mohawk Power Corporation.

O&R – Orange and Rockland. This name is used throughout this report to represent Orange and Rockland Utilities, Inc.

PA – Program administrator.

relative precision – Measures the expected error bound of an estimate on a normalized basis. It must be expressed for a specified confidence level. The relative precision (*rp*) of an estimate at 90% confidence is:

$$rp = 1.645\,\frac{cv}{\sqrt{n}}\sqrt{1-\frac{n}{N}}$$

where *n* is the sample size, *N* is the population size, and the coefficient of variance is *cv* = standard deviation / estimate mean value. The square root expression at the end of the equation is the finite population correction factor, which becomes inconsequential and unnecessary for large populations.

single-family dwelling – A dwelling with one-to-four units.

spillover (SO) – Reductions in energy consumption and/or demand caused by the presence of the energy efficiency program, beyond program-related gross savings of participants and without financial or technical assistance from the program. There can be **participant** and/or **non-participant** spillover. **Participant spillover** is the additional energy savings that occur when a program participant independently installs energy efficiency measures or applies energy-saving practices after having participated in the efficiency program as a result of the program's influence. **Non-participant spillover (NPSO)** refers to energy savings that occur when a program non-participant installs energy efficiency measures or applies energy-saving practices as a result of a program's influence.

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